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DISEASES OF VEGETABLES

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Potatoes—Late Blight on Tubers

Beans—Pod Spot

Tomatoes—Late Blight

Tomatoes—Blossom End Rot

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DISEASES OF VEGETABLES

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INTRODUCTION

The object of this bulletin is to furnish vegetable growers with information that will enable them (1) to identify the more common diseases of vegetables and (2) to apply in each case the control measures which experience has proved to be most effective.

Experiments are being carried out every year in an attempt to discover better methods of control for insects and diseases attacking vegetables. The control measures that have been the most satisfactory are given in the Vegetable Protection Calendar which is revised each year. The calendar should be used along with this bulletin. It may be obtained by writing to the Department of Botany, Ontario Agricultural College, or to the office of the Agricultural Representative in your County.

THE NATURE OF DISEASES

The majority of diseases of vegetables may be classed as: (1) Fungus, (2) Bacterial, (3) Virus, (4) Non-parasitic and Soil Deficiency Diseases.

Fungus Diseases. These are caused by minute colorless plants known as fungi. They obtain their food from green plants injuring them in various ways. These fungi produce minute microscopic structures called spores. (The spores of fungi take the place of seeds in higher plants). They are spread in various ways and come in contact with growing plants (host plants). The spores then germinate and send out tiny threads (germ tubes) which gain entrance to the growing plant. Once within the plant the little threads (mycelium) draw their nourishment from the plant, grow rapidly, and cause a diseased condition. When a fungus has gained entrance to a plant it is seldom that anything can be done to kill it without injuring the plant. Prevention, therefore, and not cure, is the object in view when dealing with the great majority of fungus diseases. One of the chief means of prevention is by thorough spraying or dusting with a substance known as a fungicide. The fungicide on the surface of the growing plant is poisonous to spores. This prevents them from germinating and penetrating the plant.

Bacterial Diseases. These are caused by bacteria which are minute one-celled plants. They are not visible except through a microscope which magnifies them several hundred times. They are dispersed by wind, water, insects, and seeds, also by implements and the hands of workmen. Bacteria enter the plant chiefly through small openings (stomata) sometimes called "breathing pores." They may also enter through wounds made by insects and during cultivation. Comparatively few bacterial diseases can be prevented by spraying or dusting.

Virus Diseases. These are not caused by fungi, nor by bacteria, nor by any organisms that can be seen with an ordinary microscope. It is believed that they are caused by a "something" in the juice of a diseased plant. This "something" is called a virus and if transferred under certain conditions to a healthy plant of the same kind, may cause the disease. Some

of these viruses are carried from plant to plant on implements, pruning knives and on the hands of workmen. Most of them are carried by insects. Plant lice (aphids) are the chief carriers. A few of these viruses are carried over from season to season in the seed. Some important viruses are carried over in perennial weeds. Many of them infect a great many kinds of plants belonging to different families, thus the problem of control is greatly complicated. Spraying will not prevent virus diseases except when spraying is done to destroy the insects that carry the viruses.

Non-Parastic and Soil Deficiency Diseases. On many occasions an abnormal condition develops in plants. This is often due to soil conditions not being suitable for the growth of the plant. The plant may not be receiving the amount of moisture required for proper development or the soil may be lacking in one or more of the elements which the plant requires.

FUNGICIDES

Fungicides are used (1) as seed disinfectants and for seed protection, (2) to control "Damping Off" and (3) as sprays and dusts for the protection of growing plants.

When a fungus is carried on the seed, seed treatment is often advisable before sowing. Where such is the case the treatment is given under "Control" for the disease. Seed sown in contaminated soil requires protection from the soil fungi during germination and until the young plants become well established. Where this is advisable the treatment is given under "Control" for the disease.

For seed treatment and seed protection the following are some of the common fungicides used:—(1) **FORMALIN** (Formaldehyde) is used at different strengths. It is a clear liquid and can be purchased in a drug store by the pound (16 oz.) or by the pint (20 oz.). (2) **CORROSIVE SUBLIMATE** (a mercury compound) is used at different strengths. Where suggested for use in this bulletin the strength is given. Mercury compounds are poisonous and should be used with great care. (3) **SEMESAN** (an organic mercury compound), directions are given with the package. (4) **CUPROCIDE** (copper oxide—a copper compound) should never be used on members of the Mustard Family such as Cabbage, Cauliflower, Turnip, or related plants, nor on onion seed or lima beans. (5) **ARASAN** and **SPERGON.** These compounds do not contain either mercury or copper. If used follow the directions of the manufacturer.

Very often fungi in the soil cause great damage to the seedling plants by "Damping Off" and treatment of the soil is necessary. (See section under "Damping Off", page 52.

Many fungicides are used for spraying or dusting growing plants. Some of these are given below.

Copper Sprays. (1) Bordeaux mixture is the most common and is very effective. It should be made up fresh when required and not kept from one day to the next. Prepared Bordeaux (dry) can be purchased in packages and is often more satisfactory for small gardens, but it is more expensive than the home prepared mixture. To prepare Bordeaux mixture: a common formula used is 4-4-40 (4 lbs. of blue-stone, 4 lbs. of fresh hydrated lime and 40 gallons of water). Dissolve the powdered blue-stone in water. Fill the sprayer about three-quarters full and add the dissolved blue-stone. Then while agitating the solution sift in the hydrated lime, and complete filling the tank with water. A poison may be added to control insects. Always wash out the sprayer well after using.

(2) Burgundy Mixture is prepared in the same way as Bordeaux mixture using 4 lbs. blue-stone, 5 lbs. washing soda (sal soda), and 40 gallons water.

Fixed Copper Sprays. "Insoluble" or "Fixed" Copper Sprays are preferable to Bordeaux mixture for some plants such as tomatoes and cucumbers, as they cause less damage to the foliage. Use as recommended by the manufacturers. A poison may be added to control insects. (See the Vegetable Protection Calendar).

Organic Fungicides. There are several of these on the market. Use as recommended by the manufacturer. (See the Vegetable Protection Calendar).

Copper-Lime Dusts. One of the dusts often used on vegetable crops is composed of 20 parts of monohydrated copper sulphate and 80 parts of hydrated lime. Most growers prefer to purchase this dust ready mixed. To control insects a poison may be added to the copper-life dust but not D.D.T.

Fixed Copper Dusts. The "Fixed" Compounds used as sprays are often mixed with inert materials and used as dusts. To control insects a poison is added by the manufacturer to these dusts.

Sulphur Dusts. Are also on the market but are seldom used for vegetable crops as most vegetable diseases are controlled better with copper fungicides.

ASPARAGUS

RUST

Caused by *Puccinia asparagi* D.C.

At one time this disease caused severe injury to asparagus in many parts of the province. Today it is of comparatively little importance due to the introduction of varieties resistant to rust. It may, however, be present occasionally. The tops of diseased plants become covered with reddish or black lines or spots. These prevent normal food manufacture, thus decreasing the yield the following season. The rust fungus winters over as spores on the old diseased tops. These cause infection of the young shoots in the spring.

CONTROL

Rust Resistant Varieties, Clean Culture and Close Cutting

Only resistant varieties should be planted. Vineland 35 and Mary Washington are the most resistant. Palmetto and Argenteuil are fairly resistant. Care should be taken to get truly resistant varieties from a reliable source. During the cutting season all shoots should be cut, even the wild ones in the neighborhood. Cut and burn diseased tops late in the fall. Plant pathologists in the state of Illinois recommend a spray with a one per cent solution of Elgetol in place of the burning. This spray is put on the old plants either in the fall or spring, applying 500 to 600 gals. per acre and at a pressure of 400 pounds.

Bean Anthracnose Pods, showing the spots characteristic of the disease.
(Courtesy of the Department of Plant Pathology, Cornell University.)

BEANS

ANTHRACNOSE OR POD SPOT

Caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Bri. & Cav.

This is the most common and most serious fungus disease of beans in Ontario. Pods, seeds, leaves and stems are affected. The pods show the most characteristic symptoms. On these are seen sunken reddish black or brown spots usually with rusty red borders. In the centre of these spots a pinkish colouring may be noticed frequently. Affected seeds show dark brown or rusty discoloured spots. These are often very minute. Portions of the main veins on the lower surface of the leaves become brown and rusty.

The fungus which causes this disease passes the winter chiefly in the bean seed, also to some extent in the bean straw and in the diseased bean refuse left in the field. It will not continue to live in the soil after the refuse from the bean crop has disappeared. The fungus is not known to attack any weeds or other farm crops grown in Ontario.

When infected seeds are sown the fungus in them becomes active and the first crop of spores of the season is produced on the seed leaves (cotyledons) of the seedlings. From these they spread to the true leaves and stems and later to the developing pods. The fungus produces spots on the pods and infects the new seed beneath the spots. The spores of the fungus are held together on the surface of the affected parts by the gelatinous nature of the spore coat. When the beans are wet with rain or dew the gelatinous substance is dissolved and the spores are scattered. As water is necessary for the liberation of the spores, the disease is always worse in rainy weather. It develops rapidly when the humidity of the air is high and the temperature is between 65° and 75° F.

CONTROL

Use a Resistant Variety, Cultivate Only When Dry, Select Seed From Disease-Free Pods, Practise Crop Rotation and Sanitation.

Varieties of snap beans resistant to Anthracnose are few in number.

Varieties of dry beans which show a marked resistance to Pod Spot are the Robust Pea Bean, Wells Red Kidney, Perry Marrow, and the Geneva. (See the Vegetable Protection Calendar). Breeding is being conducted on a large scale and promises to increase the resistant strains that are already available. In gardens healthy seeds can be procured by picking ripened pods which are perfectly free from all spots or specks. Clean seed, however, is not enough to insure a healthy crop. It must be planted far enough away from other bean fields so that the spores will not be carried from the diseased plants to healthy plants grown from clean seed. A three or four year rotation with other crops does much to prevent Anthracnose. In regard to sanitation: Plow under in the fall all diseased refuse and never use bean straw for manure with the bean crop. It is not advisable to work among beans when they are wet with rain or dew as the spores of the fungus which causes the disease are scattered at this time.

DRY ROOT ROT

Caused by *Fusarium spp.*

This is a serious disease which appears to be on the increase in Ontario. Diseased plants are stunted and may turn yellow, wilt and die early. When affected plants are pulled the tap roots are seen to be brick red in colour and are hollow and dry, with the side roots badly decayed.

The fungus which causes Root Rot lives in bean refuse and also in the soil for several years. It is spread by tools, horses' hoofs, in bean straw and manure, also by rain and floods. The disease, however, appears to spread rather slowly.

CONTROL

Practise a Long Rotation of Crops and Use Care in Disposing of the Bean Straw and in the Use of Manure on Bean Fields

The disease can be held in check by a six-year or longer rotation and by seeing that no bean straw or manure from stock fed on bean straw is applied to fields in which beans are to be grown within six years years. Any diseased refuse left on the field should be turned under deeply by fall ploughing. Beans should be planted only on well drained, well fertilized soil. If Root Rot appears cease cultivation at once. Seed treatment and spraying are of no value in the control of Root Rot. Yellow Eye beans and Refugees are said to be very susceptible and should not be planted in infested soil. Robust beans are recorded as being fairly resistant.

BEAN RUST

Caused by *Uromyces appendiculatus* (Pers.) Lev.

This is seldom a serious disease in Ontario though it is quite often seen on field beans. It causes slightly raised circular reddish brown or black spots on the lower surfaces of the leaves .

CONTROL

Authorities in the United States recommend the use of resistant varieties.

Beans—Bacterial Blight

BEAN BLIGHT (BACTERIOSIS OF BEANS)

Caused by *Xanthomonas phaseoli* (E. F. Smith) S.A.B.

This is a common and troublesome disease, occasionally causing a good deal of loss during certain seasons. Although chiefly a leaf spot disease the vessels may become infected, causing dwarfing and wilting of young plants. Lesions appear first on the leaves as tiny transparent dots, which enlarge later to irregularly shaped, sunken brown spots. Yellowish borders around the lesions may involve a large part of the leaf. When attacked in the young stage, the leaves become distorted and twisted and may shrivel and fall off.

When the stems are attacked, reddish longitudinal streaks develop, giving a cankered appearance. These areas become dry and brittle, the stem may break and the plant fall over. On the pods, tiny circular lesions develop which rapidly enlarge and develop into irregular, blistered areas, reddish brown in colour and slightly raised above the level of the healthy tissue.

The bacteria may penetrate to the seed. If this occurs while the seed is immature the seed becomes shrunken and discoloured. If the bean seeds are mature when attacked they become covered with an exudate from the diseased pods, which hardens like varnish. The bacteria may remain alive in this varnish-like coating for long periods of time.

The bacteria gain entrance through stomates and wounds made by insects, cultivators, wind, etc. Once inside the plant, under suitable weather conditions, they spread rapidly into the surrounding tissue, eventually producing the cankered and discoloured lesions. The bacteria are carried over in bean stubble, soil and infected seed.

CONTROL

Use Only Disease Free Seed. Cultivate When Dry.
Crop Rotation.

Sow only disease-free seed obtained from reliable sources. Seed should be selected from pods showing no signs of the disease. Practise a good rotation of crops, taking care not to plant beans on infected soil for at least three years. Seed treatment is of little avail but storing seed for two or three years before sowing may reduce infection. Late planting tends to reduce susceptibility to blight.

Bean Leaf—Mosaic

MOSAIC

Caused by a virus.

This is chiefly a disease of field beans. It sometimes causes serious loss especially to pea beans, many strains of which have had to be discarded on account of their susceptibility to it. Wax beans and green pod bush beans are also subject to Mosaic but it has not given serious trouble on these varieties in Ontario. Badly affected plants are stunted and sickly yellow in colour with the leaves puckered and mottled with alternate light green and dark green patches. The virus is carried over the winter in the bean seed and probably also in white sweet clover plants. It is spread chiefly by plant lice (aphids) and to some extent by cultivation.

CONTROL

Use a Resistant Variety, For Seed Purposes, Rogue Out Diseased Plants.

Most of the snap beans are resistant and suffer little from Mosaic. Among the field beans the Robust pea bean is considered as being resistant to the virus causing Mosaic in Ontario. (See the Vegetable Protection Calendar).

BEETS

LEAF SPOT

Caused by *Cercospora beticola,* Sacc.

This disease is very common in Ontario but seldom does any serious injury to garden beets. In some seasons it severely injures the leaves and crowns of sugar beets and mangels. It is easily recognized by the small, white or brown spots with purple or brown margins. Sugar beets severely injured by this disease develop long crowns and are not desirable for sugar purposes. The casual fungus passes the winter on the seed and on old infested refuse in the soil.

CONTROL

Crop Rotation and Disposal of Crop Refuse.

Plow under the old leaves in the fall. Do not grow beets or closely related plants (mangels and swiss chard) on the same ground more than once in three or four years. In small gardens rake up the diseased leaves and burn them or feed them to cattle. If the leaves of sugar beets and mangels are placed in the silo, the fermentation will destroy the organism.

RHIZOCTONIA ROOT ROT

Caused by *Rhizoctonia sp.*

The crown of the root is affected. The base of the stems of the leaves turns black and the leaves collapse and die. The fungus often penetrates the crown of the root causing the flesh to become brown and the skin cracked. The same fungus often causes "Damping Off" in seedling beds of other vegetables.

CONTROL

Provide Good Drainage and Rotate Crops.

Rotating beets with onions, sweet corn, green peas and other resistant crops will do much to lessen this trouble especially if the soil is well drained. Potatoes, tomatoes or lettuce should not be grown in this rotation as the same fungus affects them.

Club Root of Cabbage (Original)

CABBAGES AND CAULIFLOWERS

CLUB ROOT

Caused by *Plasmodiophora brassicae*, Wor.

This is a disease of cabbages, cauliflowers, turnips, radishes and other members of the Mustard Family (Cruciferae). In most of Ontario, especially in non-acid soils, it has not been serious but it has caused considerable loss in certain market garden areas.

Affected plants are noticed to flag or wilt markedly and if their roots are examined, irregular thickenings and knob-like swellings are found on them. Seedlings are often attacked. Young plants may be killed and older ones may fail to produce marketable heads.

The fungus which causes Club Root may remain in the soil for several years. It is spread in seedling plants, in contaminated manure, on implements and on the feet of man and animals. It may be washed from high to low land by running water. It does most damage on poorly drained acid soils.

CONTROL

Do Not Plant Seedlings From Infected Flat or Seed Bed. Apply Lime as Indicated by Soil Test. Use a Long Rotation of Crops.

Important measures in the prevention of this disease are: (1) The choice of well-drained soil, (2) The destruction of weeds belonging to the Mustard Family, (3) Precautions to prevent the planting of infected cabbage and cauliflower seedlings, (4) Practice of a long rotation of crops omittting cabbage, cauliflower, turnips and other members of this family.

The location of the seed bed should be such that it is not subject to being washed by water running down from higher ground. Its position should be changed from time to time or the soil in it renewed or sterilized with steam. All seedlings should be carefully inspected for any evidence of Club Root. If any infected seedlings are discovered, all of them should be discarded as many of them will probably develop the disease after they are planted out. Inspect the cabbage and cauliflower fields from time to time and if a few diseased plants are found, pull and burn at once.

If seedlings must be grown in infested soil, corrosive sublimate should be used to disinfect the soil around the roots of the seedling plants. For cabbages use 1 oz. to 10 gals. of water and for cauliflowers use 1 oz. to 15 gals. of water for the first application, and 1 oz. to 10 or 12 gals. for later applications. The first application should be made as soon as the plants are through the soil. Four or five applications should be given at weekly intervals. A watering can with the sprinkler removed can be used to apply the corrosive sublimate along the rows.

If it is impossible to follow a long rotation of crops, and cabbage or cauliflower plants are to be set out in an infected field, the ground should be plowed and an application of hydrated lime or quick lime should be made six to eight weeks before plants are set in the field. The amount of lime added should be sufficient to make the soil slightly alkaline (pH 7.2 or higher). The amount can only be determined by testing samples of the soil. Soil samples may be sent to the Soils Department, Ontario Agricultural College. It is not advisable to add lime, if potatoes are to be grown in the rotation.

CABBAGE YELLOWS

Caused by *Fusarium conglutinans*, Wr.

This disease occurs from time to time in gardens in Ontario and sometimes ruins the greater part of the crop. It is often hard to distinguish it from the bacterial disease, Black Rot. Seedlings may be killed by it. The seed leaves (cotyledons) turn yellow and the whole plant dies. Older plants which are affected are easily recognized. They are sickly yellow and stunted. The lower leaves usually drop one by one beginning near the base of the stem so that if the heads form they will be on the top of naked stalks. Often when defoliation occurs there will be a few small leaves at the tip of a bare stalk instead of a solid head. A cross section of a cabbage stem affected with Yellows shows a ring of discoloured conducting tissues (vascular bundles) similar to that found in the stem of a cabbage affected by Black Rot but not quite so jet black in colour.

The fungus which causes Yellows lives from year to year in the soil. Once established in a field it remains there indefinitely. It enters the cabbage plant through the roots and spreads upwards through the conducting tissues. The fungus develops best at high soil temperatures.

CONTROL

Use Resistant Varieties.

The use of resistant varieties is the only effective control measure. Fortunately many resistant varieties and strains have been developed in the United States. Growers should select those that are suitable to their own locality. (See the Vegetable Protection Calendar).

Cauliflower—Whiptail

CAULIFLOWER — WHIP-TAIL

Caused by unfavourable environmental conditions usually an acid soil.

This trouble is seen from time to time in Ontario in certain truck growing areas and has caused considerable loss.

Whip-Tail is easily recognized by the long narrow distorted leaves which are thick and brittle. Badly affected plants fail to head.

CONTROL

Have Soil Test Made and Apply Lime if Necessary.

Test the acidity of the soil and, if necessary, apply lime to get a soil reaction nearly neutral. The lime should be applied in such a manner that the sub-soil as well as the top soil is made alkaline.

CAULIFLOWER — BROWN HEART

Caused by lack of available boron in the soil.

The first symptom is a rolling of the leaves which become brittle and break easily. In severe cases plants are dwarfed. The young leaves have an enlarged midrib and no leaf blade. The curd may be brown in appearance. The brown colouring may extend down into the stalk which may become hollow. The internal appearance may resemble the water-soaked areas seen in brown heart of turnips.

CONTROL

An application of 10 to 12 lbs. of boron per acre to the soil has controlled the trouble in some areas. Boron should be applied early in the season though it has given some control if applied when the heads begin to form.

BLACKLEG

Caused by *Phoma lingam* (Tode) Desm.

This disease affects cabbages, cauliflowers, Brussel sprouts, Swede turnips (rutabagas), rape, radish and several other cultivated plants of the Mustard Family. In this province cabbages and cauliflowers are the only vegetables which are severely affected.

The fungus attacks all parts of the plant. Ash grey spots develop on the leaves and stems. The affected areas at the base of the stem become dark in colour hence the name "Blackleg". The fibrous roots decay and this causes a stunting and often wilting of the plants. Within the affected areas on the leaves and stems numerous back dots appear. These contain the spores which spread the disease. The fungus is carried over winter by infected seed and by cabbage and cauliflower refuse.

CONTROL

Use of Disease-Free Seed or Treated Seed. Seed Bed Sanitation. Destruction of Crop Refuse. Crop Rotation.

The disease may start in the seed bed and with plenty of rainfall may develop rapidly. It is not advisable to set plants in the field that have been grown in a seed bed in which the disease has developed.

Disease-free seed may be obtained from the Puget Sound district on the Pacific Coast in the United States. If the source of the seed is unknown, it is advisable to treat with hot water or with corrosive sublimate (see below).

Crop refuse. If the crop has been diseased, the refuse should be raked up and burnt otherwise it may become a source of infection for the next crop. Manure containing crop refuse should not be put on the field intended for cabbage or other plants of the Mustard Family. A rotation of crops should be followed in which plants of the Mustard Family will not be grown more than once in four years.

Seed treatment. Hot water—this is the most effective but it reduces the germination considerably. Place the seed in small cheese cloth bags (do not fill the bags more than half-full). Immerse the bags in hot water at a temperature of 122° F. for 20 minutes. A thermometer is required to determine the temperature. Keep the water stirred and at this temperature by adding more hot water when required. When the bags are removed dip them in cool water and spread the seed out to dry.

Corrosive sublimate treatment—this treatment is only fairly effective. It will kill the fungus that is on the surface of the seed, but not the fungus threads (mycelium) that may be within the seed. This substance is poisonous and it will also destroy metal. Use a wooden pail or a stone crock. Dissolve one tablet in a pint of water or one ounce of the powder in 6 gals. of water. Immerse the seed in the cheese cloth bags in this solution for 30 minutes, then wash the seed in clean water and spread out to dry.

BACTERIAL WILT (BLACK ROT) OF CABBAGES AND CAULIFLOWERS

Caused by *Xanthomonas campestris* (Pammel) S.A.B.

This is a disease occurring wherever cabbages and cauliflowers are grown and losses may be as high as 40 to 50 per cent. It not only causes

Bacterial Wilt of Cruciferae (Black Rot of Cabbage).

1. Cabbage leaves affected with the bacterial wilt or black rot. The lighter-shaded areas around the outer edge of the leaves are the diseased parts showing natural inoculation through the water pores on the edge of the leaves; the light-shaded areas were yellow.

damage in the field but also in storage. Other plants attacked by this disease are turnips, kale, rape, radish, Brussel sprouts and Kohlrabi.

Infection may take place at any time from the seedling stage to the mature plant. The first symptom is a yellowing of a part of the leaf, followed by a blackening of the veins. The diseased area becomes thin and brown with the blackened veins standing out clearly. Infected leaves may fall, leaving darkened leaf scars and tufts of distorted leaves at the top of the stem. On slender petioles the blackened bundles show as dark stripes. On turnips, cut sections show blackened bundles from which bacteria will ooze in masses. Plants may become dwarfed and misshapen and often infected plants are readily attacked by other secondary organisms, resulting in rapid rotting of the plant.

The bacteria gain entrance generally through the water pores on the margin of the leaves. They make their way into the vascular system (conducting tissue), travelling up and down the vessels, thus choking off the food supply from the rest of the plant. The bacteria over-winter principally in infected leaves, stems, roots and seed, and are carried from plant to plant by cabbage butterflies, aphids and slugs.

CONTROL

Use Disease-Free Seed or Treated Seed. Seed Bed Sanitation. Crop Rotation. Destruction of Crop Refuse.

Being mainly a seed-borne disease, the use of disease-free seed is important. All seed suspected of being infected should be treated with cor-

rosive sublimate 1:1000 (1 tablet in 1 pint of water or 1 oz. in 6 gals.) for 30 minutes, or dusted with an organic mercury (Semesan). This may be done by shaking the dust with the seed in a large bottle. Do not fill the bottle more than half full to allow space for shaking. Use half level teaspoonful of the dust to 1 lb. of seed. Semesan is poisonous, so use with care.

Sanitation and careful handling of transplants in the seed bed and field are important and plants showing signs of the disease should be pulled up and burned. Spraying to destroy slugs and insects is recommended. All weeds of the Mustard Family should be destroyed and all crop refuse should be gathered and burned. Crop rotation should be practised and no plants of the Mustard Family, such as cabbage, cauliflower, turnip, rape, etc., should be planted on soil that has grown crops suffering from the disease until at least four or five years have elapsed. No cabbages, cauliflowers or turnips showing signs of the disease should be stored, as extensive rot may develop from secondary fungi.

CELERY

CELERY BLIGHTS

Three different blights attack celery in Ontario.

(1) Late Blight caused by *Septoria apii*, (B. & C.) Chester
Septoria apii-graveolentis, Dorogin

(2) Early Blight caused by *Cercospora apii*, Fres.

(3) Bacterial Blight caused by *Pseudomonas apii*, (Jagger) S.A.B.

Late Blight or Septoria Leaf Spot. This is the most common and most destructive of celery diseases. In wet seasons it is very severe and ruins large quantities of celery. It may start in the seed bed or in the field soon after the plants are set out. Brown spots develop on the leaves and leaf stalks. In these spots may be seen tiny black specks. Within the black specks thousands of spores are produced and as they are scattered they spread the disease to other plants. The disease may continue to develop during cool weather in the fall and even in storage.

Early Blight or Cercospora Leaf Spot. This disease is of less importance than Late Blight but sometimes it becomes severe. On the leaves and leaf stalks dead ash-grey velvety spots develop. Spores develop on the surface of these spots, not within black specks as in Late Blight. The disease develops most rapidly during warm, moist weather with heavy dews and is checked by cool weather during the fall.

Bacterial Blight or Leaf Spot. This is sometimes very destructive. Like Late Blight it may start in the seed bed or in the field soon after the plants are set out. The spots which develop on the leaves are more reddish brown than those of Late Blight and have a yellow halo around them but no black specks within them.

The organisms causing all three celery blights live over on diseased plant refuse in the soil. They are spread when the plants are wet with dew or rain especially if cultivated at this time.

Late Blight of Celery (Small Spot Form).
(Courtesy of the Department of Plant Pathology, Cornell University).

CONTROL

Spray With Burgundy 4-5-40, or Bordeaux 4-4-40, or With a Fixed Copper, or Dust With a 20-80 Copper-Lime Dust.

Spraying or dusting should be started when seedlings are about two inches high and followed by weekly applications throughout the season especially if the weather is wet. In addition to spraying or dusting, the following precautions should be taken: (1) Plant celery in well drained land, (2) Rake and remove from the field diseased leaves and stems, (3) Follow a system of crop rotation, (4) Do not cultivate when plants are wet, and keep the soil from getting into the crowns of young plants.

FUSARIUM YELLOWS OR WILT

Caused by *Fusarium apii*, N. & C.

This disease has been observed in several of the celery growing areas in Ontario. Affected plants are stunted with yellow or yellowish white leaves. The veins (vascular bundles) in the part of the stalks (petioles)

near the crown are reddish brown or yellow in colour. The fungus lives over in the soil from year to year. There is also a virus disease of celery called Yellows.

CONTROL

Use Resistant Varieties.

All of the green varieties such as Giant Pascal, Utah, and Paragon are fairly resistant, also Cornell No. 19 (semi-green). The following yellow varieties have been bred or selected for resistance: Michigan Golden, Florida Golden, Resistant Golden Plume and Golden Pascal.

BLACK HEART

Non-parasitic. Caused by excessive soil moisture, high humidity, and high temperature.

In some seasons this disease causes serious loss to celery growers in Ontario. The central heart leaves develop tip burn which is followed by drying and blackening and often by secondary wet rot. Black Heart may cause sudden and severe injury any time after the plants are 6 to 8 inches high. High temperature, high humidity of the air, and excessive moisture in the soil are thought to be the chief factors causing Black Heart.

CONTROL

Use a Resistant Variety. Delay Planting of Early Crop. Rush Harvesting If The Disease Appears.

Among the more resistant varieties are: Florida Golden, Golden Phenomenal, and Golden Plume. (See the Vegetable Protection Calendar). The following precautions help to reduce Black Heart: (1) Good drainage, (2) Irrigating at regular intervals in dry seasons, (3) Avoiding excessive amounts of nitrogen fertilizers, and (4) Cutting the crop as soon as mature.

CRACK-STEM (CAT SCRATCHES)

Caused by lack of available boron in the soil.

This disease occasionally causes loss to celery growers in Ontario. The ribs or vascular bundles of the stems become irregularly cracked, ragged, and discoloured making the stems look as if they had been scratched. This condition is more likely to develop on alkaline muck soils than on acid soils.

CONTROL

Apply Borax

Light applications of borax have given good control in many cases. Care must be taken not to apply too much or severe injury may result. Fifteen to thirty pounds per acre are recommended.

In Michigan results have been obtained by an application of fifteen to twenty-five pounds of borax per acre mixed with the fertilizer and worked into the soil.

In Massachusetts results have been obtained by a side dressing of borax after symptoms of boron deficiency had developed. Signs of recovery were noted about two weeks after application of borax.

Florida growers have obtained results by adding 10 lbs. of borax to 100 gallons of Bordeaux mixture and applying this per acre of celery. One application.

Celery—Black Heart

Corn Smut on Ear and Tassel. (About one-half natural size).

SWEET CORN

CORN SMUT

Caused by *Ustilago maydis* (DC.) Cda.

This disease is familiar to nearly everyone who has grown any corn. The sweet or table corns appear to be more susceptible to it than field corn. On the ears, stalks, leaves, and tassels peculiar growths develop. These are often called "boils". They are sometimes six inches or more in diameter. In the earlier stages they are green, later they are white and polished, finally they become dark colour and break open exposing a brownish black mass of powder consisting of millions of spores.

The spores of the fungus which causes Corn Smut are scattered far and wide by the wind. They live over the winter in the soil and in manure. Corn may be infected any time during the early stages of its development but becomes less susceptible after the formation of the ears.

CONTROL

Remove And Destroy The "Boils" Before They Mature. Rotate Crops.

The removal of the "boils" helps to some extent in the control of the disease, especially where sweet corn is grown in small areas such as in gardens. To be effective the "boils" must be removed and destroyed by burning before they break open. Some of the new hybrid sweet corns show some resistance to smut and possibly may be grown to advantage. Seed treatment for the control of smut is of no value in corn growing districts where smut is present. If corn is being introduced into a district that is smut free, seed treatment with a mercury dust is advisable. It is doubtful if there is such a district in Ontario.

CUCUMBERS AND MELONS

POWDERY MILDEW

Caused by *Erysiphe cichoracearum* D. C.

In Ontario this Mildew frequently causes injury to greenhouse cucumbers. It seldom causes trouble in field crops. It shows as a white powdery growth on the leaves and stems. Affected leaves may turn brown, shrivel and die, and the fruit remains immature.

CONTROL

Ventilate Freely. Avoid Overhead Irrigation. Dust With Sulphur.

Ventilation is important. See that plenty is provided without exposing the plants to excessive drafts. Endeavour to maintain uniform temperatures; 65° F. to 70° F. during the night and 75° F. to 85° F. during the day are the temperatures favoured by many growers. Do not use overhead irrigation. At the first appearance of Mildew, dust with sulphur and repeat at weekly intervals. Spraying with a fixed copper such as cuprous oxide is also recommended for the prevention of this Mildew.

ANTHRACNOSE

Caused by *Colletotrichum lagenarium* (Pass) E.&H.

This disease is frequently seen in Ontario on cucumbers growing under glass. It is seldom seen on the field. The leaves of affected plants develop dead circular spots. These are frequently very numerous so that the whole leaf is destroyed. On the stems elongated light brown areas are observed. On the fruits, especially on the watermelon, water soaked, sunken spots appear. These often have a pink centre.

The casual fungus remains alive in the old diseased tissue in the soil or in the greenhouse. It is also known to be carried over in and on the seed.

CONTROL

Treat the Seed. Spray With a Fixed Copper. Destroy Crop Refuse.

Treat the seed with corrosive sublimate as directed for Scab. If the disease appears, wet the leaves as little as possible when watering. Spray with a fixed copper, such as cuprous oxide and repeat at weekly intervals. Destroy all plant refuse after the crop is harvested and do not plant a second crop of cucumbers in a greenhouse where the disease has caused trouble unless the soil has been thoroughly sterilized. In the southern part of the United States, 10% Fermate dust has been reported as giving good control of this disease.

STEM ROT OR TIMBER ROT

Caused by *Sclerotinia libertiana* Feckel

This is a disease of greenhouse cucumbers. It appears about the time the vines begin to bear fruit. The leaves turn yellow and wilt. Dead or discoloured areas are seen on the nodes near the base of the stem. These are covered by a white, cottony mould in which are often embedded small, hard, black, bodies known as sclerotia. The vines may rot off completely at the base or remain attached merely by the more resistant tissues (vascular bundles). Affected fruits become soft and watery and a white mould and black sclerotia may form on them.

The causal fungus lives in the soil and infects many other crops among which are lettuce, tomatoes, celery, and cabbage.

CONTROL

Sanitation. Soil Sterilization.

Remove and destroy all plant refuse in affected greenhouse, and sterilize the soil with steam.

SCAB OR POX

Caused by *Cladosporium cucumerinum* Ell. & Arth.

This disease has caused considerable loss to cucumber growers in Ontario during the last few years. It also attacks muskmelons and pumpkins. The fruits are severely injured by this disease. On the small fruits slightly sunken spots develop. These are about one-eighth inch in diameter. From these spots drops of a sticky substance exude. These spots or cankers become dark coloured with age and the centres collapse until a distinct cavity is formed. This is lined with a dark green velvety layer of the causal fungus. Sometimes adjoining spots unite forming a canker one-half inch or more in diameter. Affected leaves have water soaked spots and become wilted.

CONTROL

Seed Treatment and Crop Rotation.

To treat the seed tie it loosely in a cheesecloth bag and soak it for five minutes in corrosive sublimate solution, 1 tablet to each pint of water or 1 oz. in 6 gallons of water. Then rinse the seed thoroughly in clean water and dry carefully or sow at once. If in spite of seed treatment and crop rotation, scab appears, spray or dust with a fixed copper at frequent intervals until the first picking. If further applications are necessary, use dust and apply directly after picking.

FUSARIUM WILT

Caused by *Fusarium* spp.

This disease occurs on field and greenhouse cucumbers in Ontario. It causes wilting of the growing tips followed by yellowing and death of the entire plant. If the lower part of the stem or root is cut across, the conducting tissues (vascular bundles) are usually brown and discoloured. The causal fungus lives over from season to season in diseased crop refuse and the soil. It may attack muskmelons and watermelons, as well as cucumbers.

CONTROL

Sanitation. Soil Sterilization. Crop Rotation.

Remove and burn all diseased plants. Steam sterilize the greenhouse soil before planting another crop of cucumbers. If this wilt has caused serious loss to field cucumbers it is not advisable to grow cucumbers or closely related plants, such as muskmelons, on the same soil for several years.

Bacterial Wilt of Cucumber

BACTERIAL WILT

Caused by *Erwinia tracheiphila* E. F. Smith

This is a serious disease of cucumbers and other members of the cucumber family such as squash, melons, pumpkins, and others. The symptoms are first noticed in a sudden wilting of the plant, and the leaves and vines lose their turgidity and green appearance. Lesions may appear as dull, green, flabby patches which rapidly spread and are followed by general wilting and final drying and shrivelling of the vines. The fruit may also wilt and become shrivelled. The bacteria invade the vascular bundles and when an infected stem is cut, the contents of the vessels exude in ropy or stringy white drops in which masses of bacteria are present. This is the most striking symptoms of the disease. Other types of wilt caused by mechanical injury to the root, or by lack of moisture do not exhibit the milky white exudate.

The bacteria enter the vascular bundles through insect punctures and are carried from plant to plant by the striped and twelve spotted cucumber beetles which feed on the plant and thus inoculate it with the disease bacteria. The bacteria over winter in the alimentary tract of the beetles and if the beetles are not destroyed the disease will be present the following year.

CONTROL

Control Cucumber Beetles. Remove and Destroy Affected Plants At Once.

While diseased plants should be carefully removed and burned as soon as they are seen, the control of the disease can only be affected by controlling the cucumber beetles. To control the beetles, dust when the plants are small with 5 lbs. of calcium arsenate, and 75 lbs. of gypsum or talc (not lime) or with derris and repeat when the beetles re-appear.

MOSAIC

Caused by a Virus

This disease frequently causes very serious loss to cucumber growers in Ontario. It is known by various names such as Mosaic, White Pickle, White Wart, and Nubbin Disease.

The plants may show the trouble in any stage of their growth. If seedlings are severely diseased the seed leaves (cotyledons) turn yellow. The leaves are mottled yellow and green and the plant is stunted. Little or no fruit is set and the plant usually dies early. Generally plants do not show symptoms of the disease until they have passed the seedling stage. The peculiar yellow and green mottling of the leaves is the first symptom. The affected leaves are dwarfed and distorted and the fruit does not set properly. The affected fruits show irregular yellow areas alternating with warty green spots.

The virus which causes Mosaic can live over the winter in the seed of the wild cucumber (Echinocystis lobata Torr. & Gray) and in the perennial roots of the milkweed, pokeweed, ground cherry, catnip, and motherwort. Aphids and cucumber beetles transmit the virus from diseased to healthy plants. It may also be carried from plant to plant by workmen cultivating and harvesting the crop.

CONTROL

Destroy Host Weeds. Control Aphids and Cucumber Beetles. Rogue When Only a Few Plants Are Infected.

The host plants, wild cucumber, ground cherry, milkweed, pokeweed, petunia, motherwort, and catnip, growing in or within 50 yds. of the cucumber field or greenhouse should be destroyed. Cucumber beetles and aphids should be controlled by dusting. If infected plants are found in the crop early in the season they should be pulled up by the roots, carefully removed and burned. It does not appear to be worthwhile to destroy plants that show symptoms of the disease after they are normally full grown.

EGG PLANT

WILT

Caused by *Verticillium albo-atrum* Reink & Berth

This wilt sometimes destroys egg plants in Ontario. It is not usually noticed until the crop is fairly well grown. Affected plants are stunted and the leaves turn yellow, then brown between the veins. Some of the diseased plants remain half alive until fall. Others wilt and soon die. If the stems and roots of affected plants are cut, the woody tissue is seen to be dark brown in colour. Sometimes the base of the stem and the roots decay. The causal Fungus lives in the soil indefinitely and attacks many wild and cultivated plants. Among the crops severely injured by it are tomato, potato, and black raspberry.

CONTROL

Disease Free Seed. Crop Rotation.

Care should be taken to procure seed from disease-free fields. If a field becomes badly infested by the causal fungus do not attempt to grow egg plants on it. A new field should be selected on which no wilt-infected raspberries, potatoes, tomatoes, or other susceptible crops have been grown for ten years or more.

LETTUCE

DOWNY MILDEW

Caused by *Bremia lactucae* Reg.

This Mildew causes serious trouble in greenhouses or in cold frames where proper ventilation is not provided. It seldom causes much damage to field or garden lettuce. Yellow spots or blotches are seen on the upper surfaces of the leaves. Later these blotches turn brown. On the lower surface of the blotches a delicate, white fungus growth may be seen. As the margins of affected leaves often turn brown, some growers call this disease Brown Margins. If young lettuce is severely attacked the plants are dwarfed and yellow and useless for market purposes. Slightly affected lettuce is very liable to Soft Rot in transit and storage. The fungus requires plenty of moisture for growth as well as cool nights and relatively warm days. It lives in the soil of the beds for a considerable time but cannot withstand freezing and thawing. Outside it lives over on wild lettuce which is a winter annual. In the greenhouse or in cold frames, Mildew causes most trouble when the difference between day and night temperatures are greatest, and during cloudy weather.

CONTROL

Provide Good Ventilation. Regulate Temperatures and Grow the More Resistant Varieties.

This Mildew can be prevented to a very large extent by proper handling of the lettuce crop growing under glass. Light and air are important factors. The houses or cold frames should be constructed so that plenty of air and sunlight are available. Temperature is also an important factor and if the Mildew is troublesome the house should be kept 3° or 4° F. higher at night than is recommended under normal conditions. When watering, wet the foliage as little as possible. The leaf lettuce, Grand Rapids No. 1, is resistant and may often be grown to advantage.

DROP

Caused by *Sclerotinia* sp.

This is chiefly a greenhouse trouble, but in Ontario it often causes appreciable loss to outdoor lettuce. The most pronounced symptom of this disease is the wilting of the outer leaves which drop and fall flat on the ground. In a few days the entire plant collapses having been killed by the fungus.

The white fungus which causes the trouble may grow over the entire plant and form innumerable hard, black, bodies termed sclerotia. These are a resting stage of the fungus and they serve to carry it over from season to season. The fungus remains alive in the soil for a long time and increases rapidly in lettuce refuse left in the fields or beds where it is grown. The same fungus attacks many other kinds of vegetables. Carrots. cabbages, and celery are especially susceptible to it.

CONTROL

Soil Sterilization, Crop Rotation, and Sanitation.

Soil sterilization is the most important control measure for greenhouse lettuce. If only a few plants are seen in a bed they should be removed. taking care not to scatter any of the diseased tissue or sclerotia, and then soak the vacant spot with a blue-stone solution 1 lb. in 6 gallons of water. Keep the top soil well stirred and as dry as good growth of lettuce will permit. This helps to prevent the development of this disease. In the field a three or four year rotation with crops that are not susceptible is the most practical way of reducing loss from Drop. In this rotation such crops as hay, corn, cereals, onions or even beets and potatoes may be grown. Raking up and removing from the field all lettuce refuse will help in the prevention of this trouble.

BOTTOM ROT

Caused by *Rhizoctonia solani,* Kuhn

This disease frequently causes loss in Ontario. Head lettuce suffers most from it. The rot begins where the lower leaves rest on the ground and spreads up into the heads destroying first the blades of the leaves and then the midribs. It does not rot off the main stem of the plant. The fungus attacks many other plants. It lives in the soil and is very destructive to lettuce when the soil and leaves remain moist for some time. It develops to a great extent on diseased plants which have been left to rot in the field after the healthy plants have been harvested.

CONTROL

Long Rotations. Good Drainage. Sanitation and Dusting. Soil Sterilization In Greenhouses.

A long rotation should be followed using such crops as sweet corn, cucumbers, radishes, onions and spinach. If Bottom Rot has been very bad, if possible use the field for cereals or hay for a few years.

After the lettuce crop is harvested all discarded lettuce plants and refuse should be cleaned up and removed from the field. Soil for lettuce should be well drained and frequent shallow cultivation should be given. Weeds in the fields, along headlands and ditch banks should be destroyed. In New York State good results have been obtained from the use of dust for the control of Bottom Rot. Ethyl-mercuric phosphate dust (Ceresan) is blown under the plants by means of a special lettuce duster. This dust is poisonous and should be used with care. Avoid breathing it. One application of from 12 to 15 lbs. per acre is made two or three weeks before the crop is harvested. Certain strains of Iceberg lettuce show marked resistance to Bottom Rot and may sometimes be grown to advantage. In greenhouses Bottom Rot can be prevented by sterilizing the soil with steam.

BACTERIAL ROT OF LETTUCE

Caused by *Pseudomonas marginale* Brown

The margins of the diseased leaves become dark brown or black. These areas are at first soft and rotting but become thin and papery after two or three days. The infected margins are from one-quarter to three-quarters of an inch in width. Scattered over the leaf may be found small rust spots which may join together to form brown to black areas. The bacteria generally over winter in the soil.

Somewhat similar rots of leaves and stems of lettuce are occasionally caused by other closely related species of bacteria. The same control measures are advocated in each case.

CONTROL

Good Ventilation. Care When Watering To Avoid Splashing. Use Well-Rotted Manure. Remove and Destroy Diseased Plants.

The bacteria in the soil get on the leaves by splashing water and then they enter the leaves through the water pores, hence care should be taken to avoid splashing when watering the plants. Sub-irrigation is advised. Good ventilation will materially assist in controlling lettuce rots. It is recommended that only well-rotted manure or compost be added to the soil preceding the planting of the lettuce. All diseased plants should be pulled up and burned.

TIP BURN

Caused by unfavourable weather conditions.

This is one of the most destructive diseases with which lettuce growers have to contend. On outdoor crops it usually causes most loss in seasons when the crop develops so rapidly that it is impossible to cut it just at the right time. The edges of the leaves of affected plants die and turn brown, thus making the lettuce unsightly and hence not readily saleable. Hard headed varieties of lettuce are usually more susceptible than the loose headed and leafy varieties. It is generally conceded that Tip Burn is caused by weather conditions, the chief of which is high temperature.

CONTROL

Keep Temperature Below 65° F. Do Not Force Growth.

Information on the control of this disease is rather indefinite. The following culture methods are recommended (1) Lettuce grown under glass should not be over-watered and the house should be well ventilated and kept comparatively cool. (2) Lettuce grown in the field should have deep and frequent cultivation if the soil becomes packed by heavy rains. In experiments conducted in the United States the sparing use of potash and medium applications of phosphate have reduced the amount of Tip Burn in some fields. The Big Boston head lettuce is very susceptible to Tip Burn. Some of the recommended Iceberg strains such as 456 show some resistance.

ONIONS

SMUT

Caused by *Urocystis cepulae* Frost.

This is the most destructive fungus disease of onions in Ontario. It has become prevalent in several of the important onion growing districts of the province.

Smut develops only on onions that are grown from seed in soil containing Smut spores. It frequently destroys large numbers of the seedlings soon after they appear above ground. The leaves of affected seedlings become curled and twisted and dark streaks show within the tissues. These streaks are filled with a dark powder (the spores of the fungus). Seedlings that are not killed in the early stages often die later or produce small. distorted bulbs with black streaks.

The fungus which causes Onion Smut lives in the soil for many years. It can infect onions only for a brief time during the development of the seedlings. This time is usually about two weeks. Once seedlings have passed this stage the fungus cannot infect them. The spores of the fungus are carried from place to place on onion sets, by running water, or in the soil adhering to implements, the feet of men and animals and the roots of vegetables.

CONTROL

Apply Formalin When Seeding. Plant "Sets" That Are Free From Smut.

A formalin solution applied when the onion seed is being sown gives excellent results in the control of this disease. Formalin is applied by means of a tank and a drip attachment on the onion seeder. Use 1 pint of formalin to 10 gallons of water and apply at the rate of 1 gallon to 20 rods or 100 gallons per acre when rows are 16" apart. The formalin method for Smut control is now extensively used by commercial growers and is the only satisfactory treatment when large quantities of onions are grown. Those who wish to grow a few onions in soil containing Smut can do so by sowing the seed in Smut-free soil and then transplanting the onions after they have passed the susceptible stage. Onion "Sets" can also be planted in soil containing smut and not develop the disease. "Sets" grown from seed in smutty soil is one of the methods of distributing the disease.

DOWNY MILDEW OR ONION BLIGHT

Caused by *Peronospora destructor* (Berk.) Casp.

Onion Mildew is common in Ontario and during cool, wet summers often becomes very destructive. It is usually first noticed in Late June or July. Early crops from sets are the first to show the symptoms. Affected leaves become covered by a violet tinted, fuzzy Mildew which is easily seen in the early morning when the dew is on the plants. They very soon become pale or yellowish in spots, and drop over. In severe cases the leaves are

soon destroyed and usually become covered with a brown mould. Often a new crop of leaves develops and these also may be destroyed by the disease. From the second attack the onions seldom recover.

The fungus which causes Mildew lives over winter as dormant fungus threads (mycelium) in bulbs and sets. Winter onions in home gardens are often a source of infection for commercial plantings. The fungus is also carried over as thick walled resting spores (oospores) in the dead leaves in the soil of the onion fields. The disease is spread very rapidly by numerous thin walled spores produced on the surface of the affected leaves during damp, muggy weather of the summer months.

CONTROL

Do Not Plant Sets or Mother Bulbs For Seed Near Seed Onions. Provide Good Soil and Atmospheric Drainage and Practise Sanitation.

Plant onions on well drained soil and where there are no wind barriers such as woods, hills, hedges or a thick growth of weeds. These prevent the onion tops from drying quickly after heavy dew or rains. Rake up and burn the diseased onion refuse. Do not allow it to accumulate in heaps in the field. Varieties of onions with small tops which dry quickly do not Mildew as badly as those with large tops, and may sometimes be grown to advantage.

In the past the spraying of onions for the control of Mildew has been advised by some authorities. Spraying onions, however, is a difficult task and so far has not proved profitable for commercial planting. When onions are grown for production of seed there may be times when it is advisable to spray.

NECK ROT

Caused by *Botrytis spp.*

Neck Rot causes considerable loss to onions in storage in Ontario. Spanish types are very susceptible to it. White onions are more susceptible than either yellow or red onions. The first indication of this disease is a sunken dried out area about the neck of the onion. This area gradually increases in size until the whole bulb may be affected. If a diseased bulb is cut the coats or scales look as if they had been cooked. The flesh is soft and of a brownish colour. Between the scales a grey mass of fungus threads (mycelium) may develop. On the dried parts of the scales small hard black fungus growths (sclerotia) are often seen. These black structures may form a crust on the surface of some of the affected bulbs, usually about the neck. Some of the diseased onions often have part of their surface covered with a characteristic ashen grey layer of fungus growth. Neck Rot is typically a dry rot but frequently a soft bacterial rot follows it causing the onions to become soft, watery and ill-smelling.

The fungus passes the winter in decaying onion refuse. Bulbs become infected from the wounds at the neck during or following harvest. The infected areas enlarge while the onions are curing and after they are stored.

Onion—Neck Rot

CONTROL

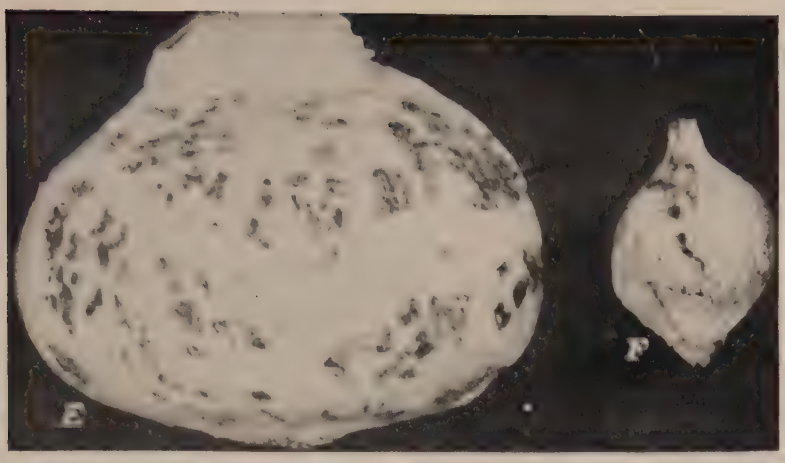
Before Harvesting Be Certain Onions Are Mature. Properly Dry and Cure The Onions and Store Under Dry Conditions.

Well dried, properly stored onions seldom develop Neck Rot. Onions should be grown so that they will mature properly. Late applications of fertilizers should not be made. Every effort should be made to grow onions free from Mildew. When harvesting cut the tops very closely and dry the stubs as thoroughly as possible before putting the crop in storage. All thick-necked bulbs or scallions should be removed. Some growers resort to artificial heat to dry their bulbs and sets. These are placed in shallow trays and held at 90° to 120° F. for 48 to 72 hours. Onions should be stored in slated crates so arranged that air can circulate freely about them. The temperature should be kept as near 32° F. as possible and the atmosphere as dry as possible.

SMUDGE

Caused by *Colletotrichum circinans* (Berk) Vogl.

In wet seasons white onions are often disfigured by this disease. It does little or no harm to yellow or red onions. It may appear at any time in the life of the onion plant, during transport or in storage, as well as in the field. It causes dark green to black smudge spots on the bulb or neck of the onions. Sometimes these smudgy spots are uniformly black. Frequently, however, the black smudging is in concentric circles. It may be so extensive as to cover the greater portion of the bulb and disfigure it very badly. The causal fungus passes the winter on onions, on sets, and in the soil. It is



Onion — Smudge

carried long distances on bulbs and on sets, and possibly on the seed. Most of the infection takes place in the field. The fungus develops best at relatively high temperatures (75 to 80° F.) and requires relatively high soil moisture. It causes most damage when we have hot damp weather shortly before harvest time.

CONTROL

Careful Harvesting and Thorough Drying of the Bulbs. Crop Rotation.

No entirely satisfactory measures are known. Careful harvesting of the bulbs and thorough drying before placing in storage help to reduce the injury. Practising a rotation of crops so that white onions are not grown on the same piece of land oftener than once in three or four years should reduce loss from this trouble. It can be avoided by growing the resistant coloured onions in place of the white or silver-skinned varieties.

PEAS

WILT AND ROOT ROT

Caused by *Fusarium spp. and Aphanomyces euteiches*, Dreschler

This disease has caused serious loss in Ontario especially in the eastern part of the province. It usually becomes noticeable at the time the peas are coming into blossom although in severe cases it may be noticed earlier than this. Often large patches in fields or even whole fields of peas will dry up and produce little or no seed. First the lower leaves turn grey or white and in a few days or a week the plants wilt down. The roots of such plants are usually brown and rotten. On the stem just above the surface of the ground there is generally a blackened area. The causal fungi are capable of living in the soil for a considerable period of time.

CONTROL

Crop Rotation. Resistant Varieties.

If the disease has been serious a rotation of crops should be followed in which peas are not grown in the field oftener than once in five years.

Several varieties of peas that are resistant to Root Rot and Wilt have been developed. See the Vegetable Protection Calendar for these.

BLIGHT, LEAF SPOT OR POD SPOT OF PEAS

Caused by *Ascochyta* and *Mycosphaerella*

This disease is easily recognized by the circular or oval discoloured spots on the leaves and the light coloured, sunken spots much like those of Bean Anthracnose on the pods. Sometimes stems of infected plants show areas of dead tissue, frequently extending completely around them and destroying the shoots.

CONTROL

Sow Non-Infected Seed and Practise Crop Rotation.

If only a small amount of seed is necessary, disease-free seed can be obtained by selecting it from healthy pods. Large quantities of non-infected seed can be secured from seed growers in the dry regions of the far western United States. Peas should be grown on well-drained land, and pea straw or other pea refuse should not be used as a fertilizer on fields where peas are to be grown. If the disease is serious in a field do not grow peas on it again for four or five years.

BACTERIAL BLIGHT OF FIELD AND GARDEN PEA

Caused by *Pseudomonas pisi* (Sackett) S.A.B.

Although responsible for severe losses in the United States this disease has occurred less frequently in Canada.

The bacteria gain entrance through stomates or wounds and cause olive green to brown lesions on stems, leaves, petioles and pods. Leaf spots become rust brown in colour while stem lesions are longitudinal, brown and cankered. Yellow droplets may appear on the cracked and cankered stems. The flowers may be killed and the young pods shrivelled. Older pods may show brown spots and cracking with an exudate which may remain on the surface, or may penetrate the seed coat. Plants attacked when young, may wilt and be killed outright. The disease is seed borne.

CONTROL

Seed From a Crop That Is Disease Free. Crop Rotation.

Practise a good crop rotation and remove infected vines and burn. Sow only seed from crops that are known to be free from disease and reduce mechanical injuries by careful cultivation.

POTATOES

LATE BLIGHT AND ROT

Caused by *Phytophthora infestans* (Mont.) De Bary

This is the most destructive fungus disease of potatoes in the province. In wet seasons it often destroys a large part of the crop. The effects of the disease are not usually noticed until late summer August or September.

Late Blight.

Early Blight.

Occasionally, however, if the weather is wet during July the disease may be observed in the fields by the middle or the end of the month. It is usually worse on low land and on heavier types of soils. (See tuber illustration on cover page.)

As the name implies this disease causes a blighting of the leaves and a rotting of the tubers. The blight is usually seen first on the margins of the lower leaves, as irregular dark blotches. They have a water soaked appearance when held up to the light. On the under surface of the leaves especially around the margin of the blotches, a delicate white fungus growth may frequently be seen. In wet weather the blotches enlarge rapidly, and the whole leaf is involved, becomes soft, brown, rotten and droops. In this way all the tops may be destroyed in a few days. On affected tubers, pits or more or less depressed areas are seen. Sometimes these have a somewhat purplish or reddish tinge and a water-soaked appearance. If the diseased potatoes are cut a rusty brown dry rot is seen in the flesh just beneath the skin. Infected tubers develop a dry rot in the field or in storage. A wet rot often follows in wet seasons. This is frequently seen when the potatoes are dug and is due to secondary organisms which gain entrance to the tubers through the dead areas produced by the fungus which causes the late blight and rot. Potatoes when dug may show no signs of rot but if they have been produced by blighted potatoes, the rot is very likely to develop about two or three weeks after they have been placed in storage.

The fungus which causes late blight and rot is rapidly spread through the crop during wet weather by means of numerous spores produced on the lower surface of the affected leaves. These spores are scattered by rain, wind and insects. The tubers in the ground may be infected by spores washed off the leaves, and down through the soil. More frequently they are infected by coming in contact with blighted tops and contaminated surface soil when they are being dug. The fungus is carried over the winter chiefly as fungus threads (mycelium) within infected tubers. Slightly infected tubers show little or no external evidence of the disease. Refuse piles of potatoes from storage houses also serve as a source of infection when these piles are anywhere near potato fields.

CONTROL

Spray With Bordeaux 4-2-40 or With a Fixed Copper, or With an Organic Fungicide or Dust With a Fixed Copper or With a Copper-Lime Dust.

In order to control insects add to the above sprays 1 lb. of 50% DDT wettable spray powder to each 40 gallons. If using a fixed copper dust use one that contains at least 2% DDT.

Caution: DDT cannot be used with a copper-lime dust, to this dust add calcium arsenate but this mixture will not control leaf hoppers.

Spraying or dusting should be started when the plants are 8 to 10" high and repeated every 7 to 10 days as long as the tops are green. Additional suggestions to prevent loss from late Blight and Rot are:—

1. Plant certified seed potatoes.

2. Avoid soils that are not thoroughly under-drained, either naturally or artificially.

3. If the vines are affected with Late Blight do not dig the crop until two or three weeks after they are dead unless a chemical has been used to kill them.

Killing the vines with a chemical before digging is often an important factor. (1) When the vines are affected with Late Blight they may be killed in order to prevent the tubers from becoming affected by the disease. The application of the chemical should be at least 10 days before digging; (2) If no blight is present and growers wish to start digging when the vines are still green, it is often advisable to use a chemical to kill them in order to make digging easier. The crop may be dug as soon as the vines are dead.

4. Remove the potatoes from the field as soon as possible after digging. Sort them carefully and store in a cool, dry cellar, spreading them out as thinly as possible. The proper temperature for storage is about 38° F.

5. Sometimes varieties of potatoes known to be resistant to blight and rot can be grown to advantage.

EARLY BLIGHT

Caused by *Alternaria solani* (E. & M.) Jones and Grout

This disease is seen nearly every year and in some seasons causes noticeable damage. Sometimes it appears when the plants are small but it

is usually most prevalent about the time the potatoes are in blossom. In severe cases the foliage is badly damaged and the tubers remain small. Unhealthy plants and those attacked by flea beetles suffer most from this disease.

It is easily recognized by the small scattered greyish-brown circular spots on the leaves. As these enlarge, faint concentric rings appear on them, described as "target" markings. Leaves which are badly spotted often turn sickly yellow.

The causal fungus is carried over the winter by means of spores in the soil and by the fungus threads in diseased potato tops and weeds belonging to the potato family.

CONTROL

Spraying or Dusting As For Late Blight and Rot, Giving Special Attention to the Early Applications.

TIP BURN OR HOPPER BURN

True Tip Burn caused by hot sunshine and warm, dry winds and Hopper Burn caused by Apple Leaf Hoppers. *(Empoasca mali)*

These troubles are very frequently seen in Ontario during hot dry summers and often cause a marked reduction in the yield. They are recognized by the fact that they cause a slight wilting and rolling inward of the edges of the leaves. The rolled edges soon turn brown. When the trouble is serious the browning and curling may extend to the midrib or near it, over a considerable portion of the leaves.

CONTROL

Spray or Dust With a Fungicide Containing DDT.

Keeping the soil rich in humus and giving sufficient cultivation to conserve moisture helps to prevent the true tip burn. The DDT helps to control the leaf hopper and other insects.

COMMON SCAB

Caused by *Actinomyces scabies* (Thax). Gussow

This scab is familiar to nearly every potato grower. It is, however, not confined to potatoes but is sometimes seen on garden beets, sugar beets, turnips, parsnips, carrots, and radishes.

It is easily recognized by the roughened corky spots on the skin of the tubers. These may be few and scattered or numerous and close together so as to distigure the potatoes badly. Sometimes there are also blackened pocket-like cavities. Scab does not injure the flesh of the tubers to any great extent but it renders them unsightly and hence not readily saleable when poatotes are plentiful.

The organism which causes Scab is carried over the winter on seed potatoes and in the soil. It remains in the soil for several years after a crop

Potato—Common Scab

of scabby potatoes has been produced. It will also pass through the intestines of stock fed on scabby potatoes. It appears to be a native to some soils. A few scabby potatoes in a bag may contaminate the whole lot. It thrives best in highly alkaline soils and those containing limestone, and is checked by acidity. It develops most readily in dry soils rich in organic matter and at a comparatively high temperature.

CONTROL

Avoid Highly Alkaline Soils and Those Containing Limestone. Plant Potatoes Free From Scab. Treat "Seed." Rotate Crops and Be Careful in the Use of Fertilizers.

It is almost impossible to prevent Scab in highly alkaline soils and those containing limestone. Therefore plant potatoes on soils that are slightly to moderately acid and hence unfavourable for the development of the scab organism. Plant only scab-free seed potatoes and treat them before planting. Seed treatment, however, cannot be relied upon to prevent Scab. If the organism causing scab is present in the soil, then scab may develop even if the "seed" was treated. Seed treatment is beneficial in some cases and helps to control Black Leg and Rhizoctonia. A crop rotation of three or four years or longer should be followed. Be careful in the use of fertilizers. Lime, wood ashes, and fresh stable manure should not be applied to soils intended for potatoes. Experiments have shown that the use of acid fertilizers, such as sulphate of ammonia, whether used alone or in a ready mixed fertilizer that does not contain lime, will gradually increase the acidity of the soil and make it less favourable to the scab organism. Where scab is troublesome, it is best to use a commercial fertilizer. If manure has to be used for potatoes it should be thoroughly rotted. It should be applied in the fall and plowed under. Green manures (rye, barley, oats, clover, etc.) plowed under have been shown to decrease scab. Never feed potatoes or peelings to stock unless they have been boiled. Potato peelings and potato refuse should not be thrown on the manure heap.

Some varieties of potatoes are more or less resistant to scab and sometimes they may be used to advantage. The russet type of potatoes are more resistant to scab than the thin-skinned white varieties.

POWDERY SCAB

Caused by *Spongospora subterranea* (Wallroth) Johnson

This disease has been found in Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Alberta and Northern Ontario. It has never become established in Southern Ontario. It does not appear to cause serious trouble in warm, comparatively dry soils. It is easily recognized from Common Scab by the scab spots which are more clearly defined, more elevated and smoother on the surface than Common Scab. When the skin of the scab spot is broken the cavity beneath is seen to be filled with a brownish or greenish powder. (spores).

CONTROL

Plant Certified Seed and As An Additional Precaution, Practise

See page 44.

Hard black lumps (sclerotia) of Rhizoctonia on Potato. (Original.)

RHIZOCTONIA OR BLACK SCURF

Caused by *Corticium vagum* B. and C.

This disease is frequently seen in Ontario and in seasons of excessive rainfall often results in a noticeable reduction of the crop. This is especially true in Northern Ontario.

Tubers affected have on the surface what appear to be hardened lumps of soil adhering to them. These are black in colour when wet, and look like small spots of tar. The skin of the potato beneath them is often roughened and russetted but the flesh of the tuber is not injured to any appreciable extent. If potatoes with these small black lumps on the surface are planted, the fungus may spread from them into developing sprouts and kill them before they get above the ground. Later in the season several other

symptoms may develop. Young shoots may wither and die and if they are pulled up and examined there will be found near the base of the stems brown, dead areas often encircling them. Sometimes large plants become sickly yellow and develop many fine spindly shoots. Occasionally at the base of the affected plants clusters of small tubers may be found and quite frequently small greenish potatoes are seen on the stem above the ground. The fungus attacks many plants besides potatoes, among which are tomatoes, carrots, beets, beans, cabbage, parsnips, onions, turnips, peas, celery, rhubarb, spinach, and lettuce. The fungus lives over winter in the soil and on the tubers. It is probable that few soils are free from it.

CONTROL

Plant Only Disease-Free Tubers and Treat Them Before Cutting.

See page 44.

Digging the potatoes as soon as possible after they are mature lessens the chance of the black lumps developing on them. This is especially true in a wet fall.

POTATO BLACKLEG (TUBER ROT)

Caused by *Erwinia atroseptica* van Hall

Blackleg occurs in most potato growing districts of North America and Europe. It is most destructive in warm, wet seasons, killing the plant, reducing the yield and rotting the tubers.

It is caused by bacteria which are found in tremendous numbers in rotting stems or tubers where they may overwinter. The seed corn maggot is known to be capable of introducing the bacteria into the lower part of the stems. The bacteria may be carried on knives, sacks, and other materials which have come in contact with the disease. Artichokes, carrots, cabbages, turnips, parsnips, and tomatoes may also be attacked.

The disease makes its appearance in early July and may continue until the end of August. The first signs of the disease are a yellowing of the lower leaves, while the upper leaves roll upwards and inwards. The stems grow erect instead of outward and affected vines and leaves become dwarfed, brown and crisp. At the base of the plant, just above ground level and sometimes extending as high as 4 inches, the stem becomes black and rotted. This stem rot (blackleg) is accompanied by considerable slime and eventually the stem becomes rotted throughout. When this occurs the upper part of the plant becomes shrivelled and falls over. The bacteria enter the tuber at the stem end; they may also enter through pore openings or wounds. In the tuber a wet progressive rot is produced which may be brown or black. Slightly affected tubers may appear sound but generally the skin is discolored, indicating rot underneath. When the rot is far advanced, the tubers may present a shrivelled appearance with the interior rotted to a soft pulp. "Puddling" of the soil around the infected tubers is typical of the disease.

CONTROL

Certified Seed. Seed Treatment. Crop Rotation.

Only certified seed from disease-free stock should be planted. Long crop rotation, pulling out infected plants as soon as they are seen during the growing season, and the use of well drained soil will assist in controlling

Potatoes—Black Leg

the disease. Late varieties have been reported to be more resistant than early. Discolored or decayed tubers should not be stored or used for seed purposes. If the cutting knife has come in contact with a diseased tuber, it should be disinfected in formalin (one tablespoon in one quart water). Potatoes used for seed purposes should be treated. See page 44.

BACTERIAL RING ROT OF POTATOES (WILT AND ROT)

Caused by *Corynebacterium sepedonica* Spieckermann and Kotthoff

This disease, first reported in Ontario in 1938, has become one of the most infectious and destructive diseases of potatoes, requiring the authorization of Government regulations to control it. It is caused by bacteria particularly virulent for potatoes. The bacteria are carried on the cutting knives, tubers, graders, sacks, and other equipment. As far as is known, the bacteria do not overwinter in the soil, but remain alive on tubers and bring about infection the following year.

The disease appears usually toward the end of the growing season and may be mistaken for frost or other injuries. The first symptoms are a wilting and rolling of the leaves which become mottled, yellow, and finally brown. Only one stem may be affected or all the leaves may be affected. Dwarfing or stunting may accompany wilting of the leaves.

The bacteria enter the tubers through the stem end and slightly affected tubers may show no external signs of the disease. Others may show a brown area surrounding the eye at the stem end and those most seriously affected present a reddish discoloration with cracking of the skin. When cut open the potatoes show stages varying from a light discoloration to extensive rotting. Yellowish brown areas are present in the vascular region, which may develop into a creamy brown, crumbly, odorless rot, which at times may be quite ropy. Secondary soil saprophytes may attack the diseased potatoes bringing about extensive rot with an offensive odor.

CONTROL

Certified Seed. Do Not Plant Any Potatoes From a Field Where Ring Rot Has Developed.

This disease can be controlled only by rigid adherence to advocated measures. Certified seed potatoes from disease free stock on land where there has not been any signs of the disease is the only safe plan to follow.

Bacterial Ring Rot is spread locally by the exchange of seed potatoes and machinery between neighbors, also by knives used for cutting the seed and contaminated second-hand bags. It is spread from district to district by means of contaminated bags and infected potatoes especially when table stock is used for planting.

Any potato grower who suspects Bacterial Ring Rot in his potatoes should send samples to the Dominion Laboratory of Plant Pathology, St. Catharines, for identification of this disease. If the disease is present he should notify the Director of Crops, Seeds and Weeds Branch, Dept. of Agriculture, Toronto, who will give directions for handling his potatoes and for eliminating the disease from his farm.

WILT

Caused by *Verticillium albo-atrum* R. & B. and *Fusarium spp.*

Plants affected with wilt are usually more spindly than normal and the foliage turns yellow. This is followed by a drooping of branches. Later the plant turns brown and dies. If the stem of a wilt-infected plant is split lengthwise a characteristic brown discoloration of the water-conducting tissues is readily seen. Tubers from wilted plants generally show a brown ring of tissue at the stem end. Tubers from slightly infected plants may be infected and not show any evidence of the disease. The fungi which cause wilt are spread by the planting of infected seed potatoes.

CONTROL

Plant Disease-Free Tubers In Non-Infected Soil.

Certified seed potatoes should be used or seed potatoes from a seed plot where thorough, careful roguing of wilt-disease plants has been practised. A field in which wilt has caused serious trouble should not be planted to potatoes again for four or five years.

VIRUS DISEASES

These are not caused by any fungus, bacterium or any organism which can be seen with an ordinary microscope. They are caused by a "something" in the juice of a diseased plant, which for want of a better name, is termed a virus and which if transferred under certain conditions to a healthy plant will cause the disease.

Plant lice or aphids are the chief carriers of the viruses that cause potato diseases. All these virus diseases are carried over from season to season in the seed potatoes. Tubers from diseased plants produce diseased plants.

The more important virus diseases occuring in Ontario are Leaf Roll, Spindle Tuber, and Potato Mosaic.

Plant in middle showing typical Leaf Roll. A healthy plant on either side for comparison.

LEAF ROLL

Potatoes infected with the leaf roll virus show various symptoms. Affected plants, however, are always more or less dwarfed and in some varieties the leaves assume a characteristic upright, almost staring habit. This symptom is sometimes absent, and instead the plants present a low-headed bushy appearance. Rolling of the lower leaves is always associated with the disease. The rolling is rather inconspicuous and may not extend beyond the leaves lying close to the ground. The rolled leaves of plants affected with this disease begin to die early. They have a harsh, leathery texture. This is a constant symptom that can be tested by feeling with the fingers. The tubers of affected plants are small and are generally borne on very short tuber branches (stolons) or even attached in a cluster to the stem.

SPINDLE TUBER

This disease shows both in the tubers and in the tops. The leaf petioles of affected plants form a sharp angle with the main stem giving the plants a dwarfed and stary upright appearance. The foliage is darker green than normal and there is no mottling. Affected tubers are cylindrical and spindle-shaped. The eyes are more numerous and shallower than normal. They even protrude slightly in severe cases. The virus which causes spindle tuber is transmitted by aphids and by the cutting knife.

MOSAICS

There are various types of Mosaics which cause mottling and crinkling of the leaves and sometimes dwarfing of the plants. When severe, Mosaic may cause a marked reduction of the crop. The virus which causes Mosaic is spread by aphids and carried over from year to year in the seed potatoes.

CONTROL

Plant Certified Seed

It pays to purchase from time to time certified seed potatoes and to plant them some distance from other potatoes to prevent these virus diseases being carried to them. If it is desired to produce seed potatoes, careful roguing should be practised.

TREATING "SEED" POTATOES

Treating potatoes helps in the control of such diseases as Common Scab, Powdery Scab, Black Scurf, (Rhizoctonia) and Black Leg.

They should be treated before they are cut and, if possible, before they have started to sprout. The treatment destroys the sprouts and hence retards growth somewhat.

A convenient method for treatment is to place one or more barrels on a sloping elevated platform in such a manner that the solution used for treatment can be drained off from the bottom of one barrel and added to another before removing the potatoes.

There are several methods for treating "seed" potatoes; only a few are given. All bags and crates that will be used to handle treated potatoes should be soaked in formalin (one pint to 30 gals. water) for two hours, unless they have been disinfected in some other way.

Acid—Corrosive Sublimate

This treatment is recommended for Common Scab, Powdery Scab, Black Scurf (Rhizoctonia) and Black Leg. The solution is made by dissolving 6 oz. of corrosive sublimate in a quart of commercial hydrochloric acid. This is added to 25 gals. of water. The solution becomes weaker with use. Soak the first ten lots of potatoes for 10 minutes and the next five lots for 15 minutes, then renew the solution. The potatoes should be immersed unbagged and spread out to dry immediately after treatment.

Caution—The acid will destroy bags and clothing and will cause burning if it comes in contact with the skin. Corrosive sublimate (mercuric chloride) is a deadly poison. Both of these substances should be handled with care and kept out of the way of children and livestock. Potatoes treated with these chemicals should not be used for food for man or beast. Wooden barrels and wooden pails or crocks should be used for handling the solution as these substances will destroy metal.

Cold Formaldehyde (Formalin)

This treatment is recommended for the control of Common Scab, and Black Leg. Either wooden or metal barrels and pails may be used as the formalin does not affect them. Add one pint of formalin (20 fluid ounces) to 25 gals. of water. Leave the potatoes in this solution for 2 hrs. The solution does not weaken with use hence several "lots" of potatoes may be treated with 25 gals. If treating on different days, it is advisable to make up a fresh solution each day.

Other Chemicals

Semesan Bel—An organic mercury compound.

Spergon—An organic compound. (See Fungicides, page6).

If these chemicals are used follow the manufacturer's directions.

Tomato Leaf—Septoria Blight or Leaf Spot

TOMATOES

SEPTORIA BLIGHT OR LEAF SPOT

Caused by *Septoria lycopersici*, Speg.

This is the most common disease of field tomatoes in Ontario. In seasons of high temperature and high humidity it causes serious loss to tomato growers by destroying the foliage early in the season with the result that the fruit does not ripen properly or is sun scalded. The disease is easily recognized by the small roughly circular spots which appear on the leaves and stems. These spots have a grey centre with a dark margin, and in them may be seen minute, black specks (the fruiting bodies of the fungus). Badly spotted leaves wither, dry up and fall off.

The fungus which causes the disease produces countless spores in the little black fruiting bodies (pycnidia) in the spots on the leaves. When the weather is warm and wet these spores are liberated and carried to other leaves or nearby plants by insects, wind, rain, and the hands and clothing of pickers. The fungus is carried over the winter in the diseased leaves and stems in the soil, and in the remains of certain weeds which are also attacked by it.

CONTROL

Crop Rotation. Sanitation and Spraying With a Fixed Copper.

Disinfect the seed bed. Any wood around the bed should be drenched with a solution of formalin 1 pint to 20 gallons of water and if Leaf Spot has been prevalent in former years the soil of the bed should be renewed or sterilized with steam. Spray the plants in the seed bed with a fixed copper, first when the true leaves are formed, and repeat at ten-day intervals until the plants are set out in the field. If in spite of the seed bed spraying Leaf Spot attacks the crop early in the season, spray in the field giving one or two applications with a fixed copper. The organic fungicides, Dithane and Zerlate show promise of being more effective for the control of this disease than the copper fungicides but Zerlate is not effective in the control of late blight. If tomato worms are troublesome lead arsenate at the rate of 2 lbs. to each 40 gallons of spray should be added.

Plow under deeply all diseased refuse immediately after harvest. Follow a three year or longer rotation with crops not belonging to the tomato family. It is said that it is easier to control Leaf Spot when legumes and cereals are included in the crop rotation. Destroy all weeds belonging to the family such as Horse Nettle, Ground Cherry, Nightshade, and Thorn Apple (Jimson Weed) which may be found in or near the seed bed or field where tomatoes are growing.

EARLY BLIGHT, TARGET SPOT, OR BLACK ROT

Caused by *Alternaria solani* (E. & M.) Jones and Grout

This disease is responsible for severe defoliation of tomatoes in Ontario in wet seasons. It sometimes causes very serious losses to the growers of canning tomatoes. On the leaves somewhat circular dark brown spots are seen. These spots are sometimes one-half inch in diameter. They are readily recognized by the peculiar ring-like or target-like markings, hence the name "Target Spot". On the fruit dark brown or black sunken rotten spots develop. Some of these may be an inch or more in diameter.

The fungus that causes this disease is carried over the winter by means of spores in the soil and by fungus threads (mycelium) in diseased tomato tops and weeds belonging to the tomato family.

CONTROL

The same as for Septoria Blight or Leaf Spot.

LATE BLIGHT, POTATO BLIGHT, OR PHYTOPHTHORA ROT

Caused by *Phytophthora infestans* (Mont.) DeBary

This fungus also causes late blight of potatoes and it is only during the last few years that it has become serious on tomatoes. On the tomatoes it causes injury to both foliage and fruit. On the leaves irregular, dull green,

water-soaked patches develop. During moist weather these enlarge and a white downy growth of the fungus may be seen on the lower surface. On the fruit small, grayish-green, water-soaked spots develop. These spots enlarge rapidly and may cover half the surface. As the fruits become older the spots become darker green, blotched with brown (mahogany colour). As the fruit ripens the diseased area becomes darker with a green border. A white downy growth may develop on the surface of the fruit especially under damp conditions. (See illustration on cover page.)

The disease is spread by spores which can be carried by the wind and it develops very rapidly in cool, damp weather, that is, when there is a combination of below normal temperatures and above normal moisture.

CONTROL

Disease-Free Plants. Crop Rotation. Sanitation. Wide Planting in the Field. Spraying or Dusting.

The spores causing the initial infection may come from diseased potato plants or diseased tomato plants that may be set out in the field. If the tomato plants are imported from the southern part of the United States they may be affected before shipping.

As the fungus causing the disease may also attack potatoes, avoid planting tomatoes near potatoes unless the potatoes are to be thoroughly sprayed.

Care should be used in the disposal of potato tubers and diseased tomatoes. If either of these are left in a pile they may be the source of infection for the tomato or potato crop.

In the field set the tomato plants wide enough to allow plenty of air space around them. When planting consider the spray machinery that may be used.

Control of the disease may depend on a program of spraying or dusting. Tomato plants should be sprayed or dusted in the seed bed every year with a fixed copper, first when the true leaves are formed and repeat at 10 day intervals until the plants are set out in the field. If the disase appears on the plants in the field or is reported in the neighbourhood start spraying or dusting with a fixed copper and repeat applications at 7 to 10 day intervals during periods of cool wet weather. Bordeaux (4-2-40) is much cheaper and more effective than fixed coppers for the control of late blight. It may cause some injury to the blossoms and for this reason it is not recommended for use until after the time of the first picking. By this time all fruits that will ripen have been set.

LEAF MOULD

Caused by *Cladosporium fulvum* Cke.

This disease frequently causes serious loss in greenhouse crops of tomatoes in Ontario. It also occurs to a lesser extent in the field. The lower surface of the leaves becomes covered with an olive brown, mouldy or felt-like fungus growth. Affected leaves turn yellow or brown and in severe cases shrivel and die.

The fungus is carried over from season to season in old diseased leaves in the soil of the greenhouse. It thrives best in a humid atmosphere and is very susceptible to temperatures. The spores germinate most readily at a temperature of from 65° to 75° F. They will not germinate in a relatively dry atmosphere. The disease becomes most severe during cloudy weather.

CONTROL

Use a Resistant Variety. Reduce Humidity By Adequate Ventilation. Destroy Heavily Infected Foliage.

The variety Vetomold 121 is highly resistant to Leaf Mould and is now recommended for the greenhouse. As the Leaf Mould can develop only in almost completely saturated air the management of the greenhouse is most important. It should be such as to keep the humidity too low for the growth of the fungus. In other words, keep the humidity as low as possible consistent with good growth of the tomato crop. This may be done by opening the ventilators and providing a little more heat. Heat is often necessary during the night as the humidity at this time is much increased. Forced ventilation by fans has been tried, but expensive, and results not very satisfactory. Avoid close planting and wet the foliage of the plants as little as possible when watering. Water in the mornings, rather than late in the day. All diseased plant material should be removed from the greenhouse and destroyed. It is also advisable to pick off the first affected leaves before the disease has a chance to spread. If Leaf Mould has been prevalent in the greenhouse it should be fumigated before another crop of tomatoes is planted in it, by burning sulphur at the rate of 1 lb. to every 1000 cubic feet. The spores may survive in the greenhouse for several months after the plants have been removed. Fumigation should not be carried on when crops are growing in the greenhouse.

TOMATO WILTS

Caused by *Fusarium* and *Verticillium*

Nearly every year Wilt causes considerable loss to growers of greenhouse tomatoes in Ontario. In some years it also destroys quite a large number of field tomatoes. Affected plants wilt from the base up. The leaves beginning with the lower ones turn yellow and wither until finally the entire plant wilts and dies. If a diseased stem is cut across, the conducting tubes (vascular bundles) are usually brown and discoloured. Moist dead stems may become covered with the pale pink fungus threads (mycelium) of the fungus.

CONTROL

Use a Resistant Variety. Sterilize Soil and Rotate Crops.

Marglobe, Pritchard, Rutgers, Pan American, and Break-O'Day are listed as varieties resistant to Fusarium Wilt. Tomato varieties developed for resistance to Fusarium Wilt may not be resistant to Verticillium Wilt. The soil of the seed bed, flats, and greenhouse benches should be sterilized with steam. When field tomatoes are grown, rake up and burn all the old diseased tops after the crop is harvested. Follow a four or five year rotation, avoiding such crops as potatoes, egg plants, and peppers.

For Verticillium Wilt the seed should be treated before sowing. Use corrosive sublimate 1 to 2000 (a tablet to one quart of water, or one half oz. in 6 gals.). Place the seed in small cheese cloth bags not more than half full—and place in the solution for 10 min. Keep the bags stirred so that all the seed will be wet. The seed should be rinsed in clean water two or three times after treating, and sown at once or spread out to dry.

BLOSSOM END ROT OF TOMATOES

Caused by unfavourable environmental conditions.

This trouble is very common in Ontario in tomatoes grown outdoors and under glass. It causes most loss to field tomatoes in seasons when periods of hot, dry weather alternate with those of heavy rainfall. It is seen first when the tomatoes are about half grown. Slightly sunken water-soaked areas appear near the tip of the fruit. These are at first lead coloured or brownish. They enlarge and soon become lead brown, or black in colour and have a leathery texture. Various fungi and bacteria may gain entrance through these injured spots and cause a soft rot which may destroy the whole fruit. (See illustration on cover page.)

This disease is caused by unfavourable environmental conditions. It has been shown to result from irregularities in the water supply. Excessive nitrogen in the soil appears to be a factor aggravating this trouble.

CONTROL

So Far As Possible Provide Even Regular Water Supply and Avoid Excessive Applications of Nitrogen

The water supply of tomatoes grown under glass should be even and regular. Outdoor tomatoes should be grown on well drained soil containing plenty of humus to retain moisture during dry weather. It is almost impossible to prevent this trouble on light sandy soils lacking humus. In dry periods cultivation should be very shallow, just deep enough to fill any cracks that may appear and to kill weeds. In wet wather the soil should be stirred enough to cause the excessive water to evaporate. Do not force the plants especially in the early stages of their development. Endeavour to maintain a state of even growth throughout the life of the plant. Avoid excessive applications of manure or other fertilizers which are high in nitrogen. Liberal applications of fertilizers high in super phosphate as 4-12-4 or 5-20-5 are said to aid in reducing loss from Blossom End Rot. Some varieties of tomatoes appear to be decidedly resistant to this trouble. Pritchard and Marglobe are two varieties that have shown marked resistance in many localities.

LEATHER END

Caused by a combination of soil and weather conditions and poor vine growth.

Leather End may be found in all tomato growing areas in Ontario but it is most troublesome in the tomato district in Eastern Ontario especially in the canning crop. In seasons favourable for the development of the disease as much as 50% of the crop has been affected. Tomatoes of the Earliana type seem to be the most susceptible.

The stem end of the tomato does not become red ripe like the rest of the tomato but becomes a greenish yellow, yellow, or bronze colour, quite hard and leathery in texture. In severe cases quarter of the tomato may be affected.

CONTROL

Soil With a Good Supply of Organic Matter To Produce Plenty of Vine Growth

The disease is worse on plants having poor vine growth or on those that have been badly defoliated and followed by a period of bright sunshine and

high temperatures. It is usually worse on the lighter types of soil. It may be reduced by shading the plants. The disease may also be reduced by having the soil in a good state of fertility with a good supply of organic matter. It is advisable to add a complete fertilizer carrying at least 6% potash and on lighter soils 10% potash. Unless a legume crop precedes the tomato crop it is also advisable to give a side dressing of nitrate of soda or ammonium sulphate about two weeks after plants are set out in the field. Plenty of vine growth is necessary for the protection of the fruit.

MOSAIC AND STREAK

Caused by a virus or viruses.

These diseases frequently cause serious loss to tomato growers. Greenhouse crops suffer most from them but Mosaic is often seen in the fields. There are two kinds of Mosaic in Ontario, Common Tomato Mosaic, and Shoe String Mosaic.

Common Tomato Mosaic. Plants affected with this disease have leaves crinkled and mottled with yellow and green. Badly diseased plants are dwarfed and usually set only a few fruits. Sometimes the fruits of diseased plants are russetted, streaked, or blotched with raised areas.

This Common Tomato Mosaic is caused by the same virus which affects tobacco and other closely related plants. It is spread by plant lice (aphids) and other sucking insects and by workmen pruning and tying the plants in the greenhouse or field. It will live in the soil for at least two months. It lives over from crop to crop in old tomato plants in the greenhouse and in the roots of perennial weeds which are closely related to the tomato plant such as Ground Cherry (Physalis spp.). It has been shown that it may live for a long time in tobacco, especially chewing tobacco, cigars, and cigarettes.

Shoe String Mosaic. Plants affected with Shoe String Mosaic have leaves that are very much dissected. Some of the leaf segments appear almost thread-like. This Mosaic is caused by the virus which affects cucumbers and many other plants. It lives over in the roots of perennial plants mentioned under Cucumber Mosaic, on page 26.

Streak. This disease causes curling of the upper leaves and the younger portions of the stems, brown sunken streaks or stripes on the vigorously growing stems and brown angular spots on the leaves between the veins. These spots may increase in size and number until the whole leaf is involved. Fruit sets very sparingly and those that do set are frequently scabby, deformed, and of poor flavour and colour. Large, soft, sappy plants are most subject to this disease.

In Ontario severe Streak is generally caused by infection of the plants by potato and certain strains of tomato or cucumber mosaic viruses.

CONTROL OF MOSAIC AND STREAK

Destroy Host Weeds. Practise Sanitation. Control Aphids. Sterilize the Soil.

All host weeds that are growing in the neighbourhood of the greenhouse, seed bed and the tomato fields should be destroyed. The chief host weeds of the Common Tomato Mosaic virus are Ground Cherry, Horse

Nettle, Black Nightshade and Purple Nightshade. The chief host plants of the Shoe String Virus are named under Cucumber Mosaic, on page 26.

All tomato refuse in the greenhouse and in and around the seed bed should be burned. Young tomato plants should not be placed in a greenhouse containing old plants. Since the virus can live in the soil the new crop of tomatoes should not be started in the seed bed or set in the greenhouse for at least four months after the crop has been removed. If possible sterilize the soil of the seed bed with steam. In greenhouses disinfect stakes using one gallon of formalin in 25 gallons of water. As far as possible control plant lice (aphids) by dusting, spraying or fumigation.

When working among tomatoes the hands should be washed frequently with soap and water and the pruning knife dipped repeatedly in formalin 1 part in 12 parts of water. Breaking off the undesirable shoots in pruning permits less chance of infection than does cutting. Always handle the healthy plants first, leaving the diseased ones until later. If only a few plants are affected, remove them at once.

Tobacco should not be used when working with tomatoes especially cigars, cigarettes, and chewing tobacco, and workmen who smoke should wash their hands thoroughly after smoking before handling tomato plants. It is not advisable to grow the following crops near tomatoes: potatoes, petunias, egg plants, peppers and cucumbers.

BACTERIAL SOFT ROT OF VEGETABLES

Caused by *Erwinia carotovora* (L.R. Jones) S. A. B.

Bacterial soft rot of vegetables is found from year to year wherever vegetables are grown. The disease may be light or serious depending upon various conditions. Those plants most commonly attacked are: cauliflowers, celery, lettuce, turnips, carrots, tomatoes, potatoes, iris, calla lily, and many others subject to the disease to a lesser degree. The bacteria gain entrance through wounds, tissue weakened by contact with the ground and insect punctures. They overwinter in diseased tissue, plant refuse, soil and manure, and are spread by handling, tools, insects, and other related means. The disease is worse in damp, warm weather when the tissues are turgid.

The main symptoms are much the same in all plants. The disease appears as a soft, slimy rot which is somewhat greyish or clay coloured, the interior of the plant may be completely rotted while the tougher epidermis may present almost a normal appearance. In the advanced stage, disintegration may be almost complete, the tissues completely rotted and the rot accompanied by considerable ooze and a putrefactive odour. Soft rot may appear in the greenhouse, field or storage bin. In cauliflowers, the flower is more often attacked and the creamy white colour of a healthy plant quickly changes to a brown, soft character with an offensive odour. When the stem is attacked, the head may fall off. In turnips, and carrots, the bacteria more frequently enter near the crown through injuries or slug attack. The disease progresses slowly in dry weather and quickly in warm damp weather, producing a brown, soft rot with a pronounced odour.

Celery and lettuce are particularly susceptible to the disease and the symptoms generally start near the tops of young growth. The disease

Bacterial Soft Rot of Celery

progresses very rapidly, producing a soft, mushy brown rot which passes down the stem or leaf, progressively rotting the tissue. Tomatoes are quickly rotted if the skin has been weakened by contact with the ground. Any vegetables stored under warm, damp conditions will develop a progressive rot similar to that in the field if they come in contact with rotting tissue.

CONTROL

The disease may be controlled by long rotation, by avoiding manure containing infected plant refuse, by drying the surface of roots and exposing them to sunshine before storage and by maintaining a constant storage temperature of 40° F. If possible diseased plants should be pulled up as soon as they are seen. Crop refuse should be burned. Care should be taken not to wound plants by careless cultivation, and slugs, caterpillars, etc., should be kept in check. Storage houses should be disinfected with copper sulphate (1 pound in 5 gallons of water) and should be supplied with good ventilation.

DAMPING OFF

Caused by fungi such as species of *Pythium* and *Rhizoctonia*

The seedlings of many plants are affected with this trouble and it often causes considerable loss. It is usually worse when plants are growing in a crowded condition especially during damp, cloudy weather.

1. Bacterial soft rot of cauliflower.

3. Bacterial soft rot of cabbage.

The chief loss is in the seed bed but the trouble may develop in a greenhouse during cloudy weather when the humidity is high and ventilation poor. The plants may be affected before they emerge or for two or three weeks after they emerge. The stems near the ground level become shrunken, the plants wilt, fall over and die.

CONTROL

Avoid Thick Seeding. Use Care In Watering. Good Ventilation. Disinfect Seed and Where Possible Sterilize the Soil With Steam.

In seed beds that are crowded, there is likely to be more "Damping Off" as the soil is kept wet and this favours growth of the fungi. Water only when necessary and during the morning rather than in the afternoon so the soil will not be wet during the night. Provide good ventilation as this keeps down the humidity of the air and also assists in drying the surface of the soil. Sometimes it is advisable to cover the soil with a layer of coarse, dry sand.

The Seed. In some cases it is advisable to treat the seed before sowing with an organic compound such as Semesan or Cuprous oxide (Cuprocide). A quart glass jar or a large bottle may be used for shaking the seed with the dust. Any excess of dust should be screened out after treating the seed.

Caution. Cuprous oxide should not be used on seeds of plants belonging to the Mustard Family, such as cabbage, cauliflower, and turnips.

The Soil. When a small quantity of soil is to be used for growing seedlings the "Damping Off" fungi can be checked by treating the soil with formalin. Use commercial formalin with 5 times as much water and half a pint of this solution to a bushel of soil. Spread the soil in a thin layer, sprinkle with the formalin solution and mix thoroughly. Place the soil in flats and leave at least 24 hours before sowing seed, and water thoroughly as soon as seed is sown. Do not transplant seedlings in this soil until all odour of formalin has disappeared.

The flats in which the soil is to be used should be sterilized by soaking them for 30 minutes in a formalin solution using 1 pint of formalin to 25 gallons of water.

Another method to control "Damping Off" is to apply a fungicide in solution to the soil after the seed has been sown and before it emerges. Semesan (1 oz. in 3 gals. water) or Cuprous oxide (1 oz. in 3 gals. of water) may be used for this purpose. An application of these chemicals may be made after "Damping Off" begins but much better if made just after the seed has been sown.

The best way to prevent "Damping Off" is to steam sterilize the soil that is to be used for growing the seedlings. This may be done by different methods. See steaming soil for growing seedlings under "Soil Sterilization" page 56.

SOIL STERILIZATION

The term "sterilization" as used here is synonymous with disinfection.

Many disease producing organisms live over from crop to crop in the soil especially in greenhouses and seed beds. The sterilization of such soils is an important factor in disease control. Care is required during sterilizing to see that all parts of the soil are thoroughly treated and also afterwards to see that the soil is not reinfected by other soil brought in from another house on contaminated boots or dirty tools. If soil becomes contaminated just after sterilizing, the disease usually develops more rapidly than if no sterilizing had been done.

There are two methods of sterilizing—one with steam and the other with formalin or other disinfectants. Steaming is preferable both for

greenhouses and for seed beds. It is more thorough, gives better control of nematodes and plant diseases and kills weed seeds. When steam is not available then formalin or some other disinfectants may be used, depending on the organisms to be controlled.

Formalin

Formalin is a clear liquid. It is a 40% solution of formaldehyde gas in water. The soil should be dug up and in a very loose condition before adding the solution. Use 1 gal. of formalin to 40 gals. of water and by means of a sprinkling can appy this to the soil at the rate of 2 qts. per sq. ft. of soil. After treating cover the soil for a day or two to help keep the fumes in the soil. A tarpaulin may be used or bags or papers that have been wet with the formalin solution. As soon as the soil is sufficiently dry, dig it up again to allow the fumes to escape. Do not set out any plants or sow any seeds for at least ten days after treating. Formalin should not be used where the fumes will reach other plants. Formalin, like many other chemical substances will not control nematodes. For treating small quantities of soil see control for "Damping Off". Page 54.

Chloropicrin

Chloropicrin (tear gas) has been used to some extent for disinfecting soil. It is a liquid chemical and should be handled with care. It is transported in cylinders and these should be opened outdoors. The gas is very poisonous to plants and should not be used where the fumes will reach them. The soil temperature should be between 60° and 85° F. at the time of treatment.

This chemical is injected into the soil with an apparatus constructed for the purpose. Two types of machines have been used. One is small and carried by hand; the other much larger, a walking tractor machine. The machines for applying the chloropicrin should be operated only by an experienced operator.

With the small machine the chloropicrin is injected into the soil in holes about 10 inches apart, an at a depth of 5 to 6 inches. The hole is filled at once and the soil pressed down. With the large machine the chloropicrin is placed in the soil in a very small stream as the machine passes along the ground.

After treatment the soil should be wet to a depth of an inch or two to form a seal and this seal should be continued for about three days. Plants should not be set in the soil until the odour of the gas has disappeared. This may take from a week to three weeks depending on the temperature and nature of the soil. Working the soil a few days after treatment will assist in the escape of the gas.

Other Chemicals

New chemicals are coming on the market as soil disinfectants but it seems to be a problem to get one that will successfully control nematodes and plant diseases. Dowfume-G has been used in some cases for nematode control but it is not recommended for the control of fungus diseases.

STEAM

Sterilizing the soil with steam is the best method that can be used. It not only destroys insects and disease organisms but it also kills weed seeds. The soil should be in a loose condition with no large lumps. It should not be too wet as it requires much more heat to raise the temperature of wet soil. Soil that is a little too dry for good plant growth is usually in a good state for steaming. The moisture content of the soil will be increased during the steaming but not sufficient to be objectionable. Soil that has been steamed usually dries out more rapidly than unsteamed soil. Care in watering is very necessary especially during the seedling stage of the plants.

Soil that is steam sterilized may be used for two purposes:

(A) Soil that will be used after steaming for pots and flats for growing seedling plants. Usually only a small quantity of such soil is required.

(B) Soil in greenhouses and in seed beds.

A—Steaming Soil For Growing Seedlings

One of the common methods is to make a tight box, something like a waggon box placed on its side. The height and length may vary but the width should not be more than 2 ft. If too wide it takes too long for the steam to penetrate to the soil in the middle of the box. The box should be constructed so that the top and one end can be taken off for filling and removing the soil. Pipes 1½″ diameter are attached to the sides of the box about 1 ft. apart and each pipe should have a row of holes ⅛″ diameter and about 6″ apart. At one end the pipes are united by a cross pipe and this is coupled to a pipe or heavy hose leading to the heating plant. Steam is passed into the soil for an hour (more or less) depending on the capacity of the boiler.

Another method is to have a box something like a waggon box with bottom and sides tightly fitted. Lay the pipes on the bottom of the box about a foot apart. There should be a pipe about 4 to 6 inches from each side to make sure that the steam will reach the soil at the sides of the box. Fill the box with soil to a depth of 12 to 15 inches and cover with a close fitting top or tarpaulin to help hold the steam. A good thermometer should be used—one that is marked to 220° F. The end of this should be placed in the soil midway between the rows of pipes and a depth of about 4 inches. In most cases the soil should be sterilized when the temperature reaches 200° but to be sure that the steam has reached all parts of the soil, it is better to steam for a while after this temperature is reached.

Another method is to have a bench in the greenhouse fitted up with pipes and with the sides and ends about a foot high, to hold the soil to be sterilized. This should be covered with a tarpaulin or other covering to hold the steam as much as possible when sterilizing.

Tile may be used in place of pipes but care is required to keep them in place when filling the soil over them. If not carefully fitted together, too much steam will escape at some places and not sufficient at others. If a small thin piece of wood, such as used for making fruit baskets, is put between the ends of the tile, it keeps them from being fitted too closely.

Care Required After Steaming

After steam sterilizing soil, great care should be taken to keep it from being contaminated as the fungi causing "Damping Off" or other diseases will develop faster in steam sterilized soil than in ordinary soil.

B—Steaming Soil In Greenhouses and Seed Beds

Various methods have been used in steaming the soil in greenhouses, but the most satisfactory are: (1) the inverted pan (2) buried pipes and (3) buried tile. With the inverted pan, the steam is applied at the surface of the soil and is forced into the ground, whereas with the buried pipes or tile the steam enters the soil at some depth and rises to the surface. With the tile method, large areas may be steamed slowly whereas with the inverted pan method, small areas are steamed more rapidly.

1. **Inverted Pan.** For outside seed beds and tobacco beds, or for small greenhouses where nematodes are not giving trouble, this method gives good results. If posts are in the way, the soil around them cannot be sterilized in a satisfactory manner and contamination of what has been sterilized soon takes place. This can be overcome to some extent by digging the soil from around the posts and spreading it out where it can be covered with the pan. When nematodes are present those near the surface may be destroyed but many deeper in the soil will remain alive.

The size and shape of the pan may vary according to the size of the beds to be sterilized. A pan 6 feet x 12 feet and 8 inches deep made of No. 16 galvanized iron, reinforced with angle iron is a convenient size to use. The area of the pan should not be greater than 3 sq. ft. per boiler horsepower. In order to move the pan, a handle or large ring should be attached to each corner. The pan should be held in place by stones or bags of sand placed on the corners. The steam should enter in such a manner that it is not forced directly into the soil at the point of entrance. The steam may enter at the central part of the pan and a "T" fitted on the inside so as to force the steam each way, or the steam may enter at one end of the pan, or a bent pipe may be used which will pass underneath the edge of the pan and the open end come above the surface of the soil underneath the pan. The pan is connected to the boiler by means of piping and heavy rubber hose.

As a thermometer cannot be used while steaming to determine the temperature of the soil, some other means may be used as a check. The old method of cooking a patato placed about four inches below the surface of the soil may be tried. When the pan is moved forward to a new position it should be placed so that it will slightly overlap the area already sterilized. It is advisable to cover the place that has been sterilized with tarpaulin or canvas for sometime in order to retain the heat and secure better penetration. Care must also be taken when moving the pan that no dirt be carried from the unsterilized area to that which has been sterlized. A threshing engine that is in good condition may be used for sterilizing with the pan system.

2. **Steam Pipes.** A number of pipes having a diameter of 1½ or two inches are used. A row of holes one-eighth inch diameter and about 6" apart is drilled along one or both sides. If on one side only, the pipes should be placed in the soil so that the row of holes will be on the underside. These pipes are placed in the soil in parallel trenches about 18 inches apart and 10

or 12 inches deep. One end of each is connected with a cross pipe which is joined to the steam line. The trenches are then filled in and steam passed through the pipes. After one area is steamed the pipes are dug up and moved to another area. This method is not very satisfactory as the trenches have to be dug and the pipes changed each time and this involves considerable labor. If sufficient piping is used to cover all of the area to be steamed, the pipes may be left in the soil but if this is done holes are likely to become plugged and the pipes rusted. During the steaming and for sometime after, the soil should be covered with tarpaulin or building paper or other material that will help to check the rapid escape of the steam from the surface of the soil.

3. **Tile.** In the larger greenhouses and where nematodes cause trouble, steaming through tile is the most satisfactory method of soil sterilization. The initial cost of the tile and installation is considerable, but when completed one has a permanent system which will save much time and labour on later occasions. The steaming should be done during the summer months as there is a much greater saving of fuel than when done during the winter months.

Trenches For Tile. Parallel trenches are dug and 3 or 4-inch field tile are laid so that the top of the tile will be about 12 inches below the surface of the soil. They should be deep enough so that when the soil is being dug up there is no danger of breaking the tile. The middle of the trenches may be from 18 inches to 2 feet apart, depending on the nature of the soil. In most cases 18 inches is the better, but if the soil is loose and open, the tile may be placed deeper and a little farther apart but never more than 2 feet in any soil. If placed farther apart it is usually difficult to get the soil midway between the rows heated to the temperature desired. This may be done but the steaming will have to be continued much longer than otherwise required and this causes excessive heating in areas closer to the tile.

Laying The Tile. The ends of the tile should not be fitted together too closely, but left a short distance apart in order that the steam is free to escape at all joints. Small thin pieces of wood such as used for making fruit baskets may be put between the ends of the tile to make sure they are not fitted too closely. A small amount of crushed stone or coarse gravel may be added at the joints as this will also assist in allowing the free escape of steam. If the tile are laid lengthwise in the greenhouse the outer rows should be laid close to the side walls and the ends of the rows should come close to the end walls. It frequently happens that the soil around the walls or along the walks is not thoroughly sterilized. These areas should be carefully checked when steaming.

Length of Rows. The length of the rows of tile depends to some extent on the capacity of the boiler to be used in steaming. Tile may be laid the length of the house and steam passed into one or two or more rows at a time. By fitting a "T" into the middle of a long row of tile the steam may enter through it and pass each way. Where a large boiler has been used satisfactory results have been obtained in houses 300 feet long, two rows of tile being steamed at the same time. The steam entered at the middle of the row and passed 150 feet each way. When long rows of tile are used, the end farthest from the entrance of the steam should be fitted with a small pipe coming to the surface of the soil. This should be left open until the steam begins to escape freely, and then closed. This is particularly necessary in heavier types of soil in order to allow the cold air in the tile to escape and thus ensure a more even distribution of steam. In loose.

open soils the cold air in the tile escapes more easily, hence it is not so necessary to have the far end of the tile fitted with a small pipe.

Although long rows of tile may be used, one end frequently heats up faster than the other, hence a loss of steam. A broken tile in the line may prevent the steam from passing, and will have to be replaced before the steaming can be completed. For these reasons it is preferable to have a number of short rows of tile coupled up in such a manner that the steam entering at one place can flow into the whole block at once. Thus in place of passing steam into one row of tile 300 feet long better results are obtained by passing steam into 10 rows each 30 feet long. If this system is followed a row of tile should be laid crosswise at both ends of the rows and coupled up with the ends of each row. When steam enters this block of tile it will circulate throughout the whole block in a short time as it can enter freely at either end of the rows of tile. If there is a broken tile in any row the steam can enter at the other end of the row.

Steam Line To Tile. The tile may be connected to the steam line in different ways. By means of an elbow and two short pieces of 2-inch pipe an "L" shaped piece may be put together. One end of this is placed in the tile and the other end above the surface of the soil. A cap should be screwed on this end to keep the dirt out when not in use. If the steam is to enter at the middle of a long row then in place of an "L" a "T" may be used. Steam may be carried from the boiler to the tile through pipes used for heating, but it is more satisfactory to run a direct line from the boiler using a 2 or 2½-inch pipe. The pipe may be connected with the piping in the soil by means of a jackknife structure and an ordinary union or by using a piece of heavy rubber hose.

Steaming. When starting to steam one should have on hand one or two good thermometers that will stand a temperature of over 212° F. (boiling point) and protected by a case so that they can be inserted in the soil. Such thermometers are expensive, but are necessary if one is to be sure of a thorough job and at the same time not waste time and fuel. A good dairy thermometer may be used, but it is not very satisfactory. After the steam has been passing into the tile for some time, one should go over the area being sterilized to see if the steam is coming through the soil all along each row of tile. It is then advisable to cover the area with tarpaulin, or building paper or some material that will prevent the steam from escaping too freely from the surface of the soil. This is more important if steaming is being done during the winter months. If tarpaulin or building paper or such like cannot be obtained, the surface of the soil my be somewhat sealed by sprinkling with water.

The length of time required to sterilize any area of soil depends upon the capacity of the boiler, the area being treated, the moisture content, and the physical condition of the soil. One thousand square feet may be sterilized by a 100 H.P. boiler or estimated roughly, 10 sq. ft. per boiler horsepower. This is about the maximum area and will require a longer time than if a smaller area is being steamed.

Most of the organisms, causing plant diseases are killed by steaming in a very short time but a few are more difficult to control. If the tile have been properly laid and steam is escaping at all of the joints, the results ought to be satisfactory when the temperature of the soil has reached 210° F. The temperature should be taken at several places between the rows of tile and about 3 or 4 inches below the surface of the soil. Some-

times it is advisable to continue the steaming for a while after this temperature has been reached as there are often spots where the steam has not penetrated as rapidly as it has in most of the soil.

As stated above the tile method sterilizes deeper than the pan hence more fuel will be required for this method. It many cases about 2 lbs. of coal per sq. ft. of soil is sufficient for the sterilizing but this amount will vary due to the condition of the soil, time of year and other factors.

Steaming usually improves growth conditions by liberating nutrients that were not available for plant growth. In rare cases, however, toxic substances may be liberated which have an injurious effect during the early stages of the crop following the steaming.

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